SCIENCE

A WEEKLY JOURNAL DEVOTED TO THE ADVANCEMENT OF SCIENCE, PUBLISHING THE OFFICIAL NOTICES AND PROCEEDINGS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

FRIDAY, MARCH 29, 1901.

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MSS. intended for publication and books, etc., intended or review should be sent to the responsible editor, Professor J. McKeen Cattell Garrison-on-Hudson, N. Y.

*THE EMBRYOLOGICAL BASIS OF PATHOLOGY.**

EMBRYOLOGY is the basis upon which pathological science must be erected. Pathology is even more a superstructure upon embryology than is anatomy. Anatomy, in its descriptive form, may stand by itself and have usefulness. Pathology cannot be built up as a merely descriptive science. It fails of its true purpose unless it discovers the causes of diseases. Now since function is dependent on structure, the aim of the pathologist must be first to discover the causes of morbid structure. In brief, pathology at the present time deals chiefly with problems of the development of anatomical forms. Pathology and embryology might almost be united in a single comprehensive study—morphogeny. Let us then try, for this evening at least, to free ourselves from the conception of an essential difference between normal and abnormal structure, a conception which, I believe, domineers too largely over our daily thoughts. This belief of mine I hope to justify to-night.

Simple description is indispensable, it furnishes the virgin facts; but facts do not develop by parthenogenesis into science; they must be saturated with the stimulus of study, with the stimulus of knowledge of their history, their antecedents, their causation, then we may see them evolving

* The Middleton Goldsmith lecture delivered before the New York Pathological Society, March 26, 1901.

themselves into new orders, which we call natural laws. As little as a description of the people of the United States with no information as to their history could satisfy a serious thinker, so little can descriptions of fully developed structures satisfy an earnest pathologist. An innate, intense mental impulse is continually driving us forward in the search for causes, and obedience to this impulse is one of the main factors in scientific progress. All this is familiar, trite even, but may serve to fix our starting thought, namely, that we are to study causes.

Our attention is to be directed to the consideration of what embryology can teach us in regard to the causation of organization, and then to the application of those teachings to pathology.

This plan will exclude from our discussion many of the aspects of embryology which appeal most strongly to pathologists. We must omit from our study at least three groups of interesting phenomena, to wit: *First*, the arrests of development; *second*, the teratological formations, monstrosities and mis-developments, which will, however, have to be included ultimately even in the precise field we are about to study; *third*, the so-called teratoma, or to use a more recent term, embryoma. I may say in passing that I find it very difficult to accept the hypothesis that these remarkable structures arise by a parthenogenetic development of ova, retained in the parent body. Professor Bonnet's hypothesis is more legitimate, but towards that also my attitude is one of sceptical agnosis. Bonnet suggests that one of the early segmentation cells (blastomeres) may become isolated and retarded in its development, remaining as an inclusion in the fœtal tissues, and afterwards develop and produce a variety of tissues, as isolated blastomeres have been shown by experiments on the lower animals to be capable of doing.

Teratological formations fall, it seems to me, naturally into three fairly definite divisions: (1) those due to necrosis of the tissues, which apparently rarely if ever takes place uniformly throughout the embryo; (2) those due to gross mechanical disturbances of the development, consequent upon failure of the proper correlation of the growth of parts; monstrosities of this division are probably the most common; (3) errors in the differentiation of the tissue or pathological histogenesis. It is only phenomena of the first and second divisions of teratology which we can safely drop from view, while those of the third division—errors in differentiation—we must bear uninterruptedly in mind.

One more preliminary explanation is necessary. The range of pathological changes is not so great as to reach equality with embryological developments. In the normal embryo we deal with the evolution of complete organs together with all their accompanying varied and complex modifications of tissue. In pathology, on the contrary, we deal not with organs, but with modifications of tissues, with histogenesis. The statement will not seem too absolute if it is recalled that we have excluded arrests of development and monstrosities from our discussion.

Histogenesis is the common territory in which the pathologist and embryologist have —to borrow a legal phrase—an undivided interest. It is unfortunate that our tendency has so long been to attempt an unnatural and impossible partition of the territory, which has resulted only in a division of our forces into two camps, between which has reigned little interest and less sympathy. I venture to regard your invitation to address you to-night as a wish, which I fully share, to secure fuller cooperation between the two camps of workers, who are both striving to lay bare the laws which govern the differentiation of cells.

After these preliminary explanations it is possible to define the evening's task with precision. It is twofold. First, to present some of the more important conceptions derived from embryological study in regard to the processes of cell differentiation. Second, to suggest some of the bearings of these conceptions on the problems of pathology.

PART I. NORMAL DIFFERENTIATION.

Under this head I propose to discuss three fundamental ideas:

First, of the undifferentiated cell.

Second, of the progress of differentiation.

Third, of the changes which may succeed differentiation.

The fertilized ovum is an undifferentiated being, although it has a very complex organization, and contains besides the protoplasm a store of nutritive material, the so-called yolk or deutoplasm. As there is only one nucleus, there can be no variety of nuclei; the term undifferentiated, therefore, applies to the protoplasm, which seems to have a uniform essential structure throughout, although the masses and strands of protoplasm may exhibit characteristic peculiarities, especially in relation to the distribution of the yolk. In the adult, on the contrary, the protoplasm of the cells of different tissues offers many varieties of essential structure, which can often be readily distinguished under the microscope. It is a legitimate conclusion that the absence of visible peculiarities of the intimate structure of egg protoplasm, by which one part may be distinguished from another, corresponds to uniformity of structure throughout the egg, excepting, of course, certain special characteristic arrangements, as, for example, the centering about the centrosome, which may occur in any cell.

We have also direct experimental proof that the egg is uniform throughout, or to use a better phrase, that the egg is isotropic. Pflüger, in 1884, proved that the side of the frog's egg, which normally develops into the ventral surface of the embryo, can be made to develop into a perfectly typical dorsal surface. The frog's egg has a small white area, which normally lies underneath, the larger darkly pigmented area of the egg alone showing from above. Out of the dark area the back with the nervous system and other parts takes its origin. If the eggs, freshly fertilized, are fastened with the white side up, then the white side produces an absolutely normal back and nervous system, normal as to form and function, though lacking the typical pigmentation. These observations were confirmed by Born, who further discovered that the segmentation nucleus always rises towards the upper side of the egg, and that the position of the nucleus determines which part of the ovum shall become the dorsal side of the embryo. Another set of experiments by Oskar Schultze demonstrated that both the unpigmented and the pigmented sides of the same egg could be made to produce dorsal structures.

Another class of experiments, which were first made by Hans Driesch, have demonstrated that the earliest cells (segmentation spheres, blastomeres or cleavage cells, as they are variously called) produced by the ovum preserve the undifferentiated qualities of the parent egg, and may develop in one way or another according to circumstances. The egg of a sea urchin divides into two cells, each of which multiplies and normally gives rise to half* of the body of the animal. By somewhat violent shaking the two cells may be artificially separated; each cell may then develop into a complete larval sea-urchin, but of half the normal size only. Similar experiments have since been made by several investigators, who have obtained like results with

* It would be safer to say supposedly about half.

other animals, vertebrate as well as invertebrate. Even more remarkable larvæ have been raised from blastomeres of the four cell and eight cell stages of segmentation, producing larvæ of one-fourth and one-eighth the normal size. Zoja claims to have repeated the experiment successfully on the eggs of *Clytia* and to have obtained one-sixteenth larvæ.

The facts offered suffice to illustrate the two aspects of our conception of the undifferentiated condition of living matter. The first aspect is morphological and presents to us the apparent uniformity of the visibly minute structure of protoplasm. While we readily admit that the uniformity may be only apparent in the sense that we fail to observe fine differences, yet we none the less maintain that the uniformity is real, because there is an absence of variations of structure comparable to the variations which we can observe in the cells of adult tissues. The second aspect is physiological and offers to our view the wide range of possibilities in the future developmental history and growth of the protoplasm. The fate of the protoplasm of any given part of the ovum is not fixed, but if its conditions of development are changed its fate is changed. A few years ago the mosaic hypothesis was advanced by W. Roux and has been vigorously defended by him. According to the mosaic theory, the egg is a mosaic pattern, each member of which has its predestined history. It is fortunate for our comprehension of pathological process that we are already able to say that Roux's hypothesis is erroneous.

We must start then with the right conception of the ovum, every part of the protoplasm of which is to be regarded as potentially capable of producing any or all the tissues of the adult.

We turn next to the consideration of the progress of differentiation in order to establish a second fundamental idea, namely, that it acts as a progressive restriction of the further development. Each successive stage of differentiation puts a narrower limitation upon the possibilities of further advance. Applied to pathology, this law means that the range of possible pathological changes is determined not merely by the nature or kind, but also by the stage or degree, of the previous differentiation of the tissue.

The eggs of all animals* pass through two well-marked phases of development.

During the earlier and much shorter phase, the nuclei are multiplying rapidly, while the cytoplasm is growing but little, if at all. This period includes the time of segmentation, as commonly described, and somewhat longer. During this period the total bulk of the nuclei in proportion to the protoplasm is fundamentally changed. The ovum arises from a cell, the ovocyte, which, as its last act, grows rapidly ; this enlarged cell, by the process of maturation gives rise to the female sexual element, which has a single nucleus. After the fertilization we have an ovum with much protoplasm and deutoplasm, but again with only the single segmentation nucleus. The development of each individual begins, therefore, with a cell in which the extreme disproportion between the size of the nucleus and of the whole cell-body occurs. The first effort of development is to correct this disproportion by the enormously rapid increase of the nuclei, which continues until cells of the embryonic type are produced, that is to say, cells each with a minimal amount of protoplasm around the nucleus. With the production of cells of the embryonic type, the first phase of development is completed. The limits of this phase are very indefinite for we observe often that the prodution of cells of the type defined may be far advanced in one part of the germ, while it is

*The protozoa are obviously excluded from the present discussion.

still in early progress in another. In fact the phase has no exact boundary in time.

During the second, later and much longer period or phase of development, the multiplication of nuclei lags behind the growth of the protoplasm; the increase is gradual and often shows itself through successive generations of cells, sometimes, however, in a single cell, which no longer multiplies. Of the first method of protoplasmic growth embryonic blood-cells offer a good illustration, of the second the neuroblasts or young nerve cells afford a striking example. Now cells of the embryonic type show little if any capacity for differentiation, and the increase of the protoplasm in the single cell is, so far as we can judge, a necessary preliminary step to cell differentiation. The embryonic cells have yet another characteristic of basal significance; they are capable of rapid multiplication. Hence we conclude that the growth of the cytoplasm impedes the multiplication of cells, and, therefore, ultimately retards the growth of the body, as a whole, while on the other hand it favors differentiation. Accordingly the growth of cells and their differentiation are essentially antagonistic processes, which are necessarily more or less mutually exclusive. This conclusion which I published in 1890, has since been amply confirmed by further observation. It is probably applicable alike to animals and plants, alike to normal and abnormal tissues. It is one of the many conclusions of embryology which are sure to throw a revealing light upon some of the dark problems of pathology.

During the first phase of development, as just defined, we encounter preparatory changes which we may characterize summarily as the manufacture of embryonic cells. During the second phase, though the production of embryonic cells is doubtless continued in certain regions, there supervenes the process of differentiation, the true histogenesis.

After segmentation there follows the formation of the germ layers, a gradual arrangement of the cells in three distinct primary strata—at least in all vertebrates there are always three strata, never more* nor less. The outer and inner layers, ectoderm and entoderm, very early become distinctly epithelial. The middle layers become partly epithelial, partly of a special character, that is mesenchymal. At first one is inclined to think of the difference between epithelium and mesenchyma as a fundamental one, an early and unalterable separation of cells into classes. This view finds support in the fact that the mesenchyma, and it only, produces in the course of further development the connective tissue and supporting tissues of the adult. More attentive study of the germ layers in early stages reveals, however, that the mesenchymal cells arise from the epithelium, single epithelial cells migrating from the parent territory, while on the other hand groups of mesenchymal cells rearrange themselves so as to form an epithelial covering of some surface, as for example, in synovial cavities, arachnoid spaces, the inner surface of the cornea, lymph vessels, etc. Such observations teach us that we must not assume that either the form or the arrangement of cells is necessarily and always a sign of true differentiation, but that instead we are to conceive of differentiation as a change in the intimate and essential structure of the individual cell, more specifically of its protoplasm, and perhaps of its nucleus. The rôle of nuclei in histogenesis is a topic which unfortunately is still awaiting serious investigation. To resume: it seems to me probable that the cells of the germ layers are at first quite

* Hertwig and some other German embryologists divide the mesoderm into two layers; the division is contrary to the actual development, and is made, in my opinion, quite arbitrarily to satisfy the needs of an erroneous theory.

indifferent, so that if it were possible to graft a young mesodermal cell on to the ectoderm or entoderm, it would become a true ectodermal or entodermal cell, as the case might be.

But although we may, so far as we now see, regard the cells in the germ layers as originally wholly indifferent as individual cells, nevertheless, we must not forget that as members of a germ layer their potential fate is already restricted by the conditions of their very layership—if I may coin a word for the occasion. Each layer produces its own group of tissues and never any other. There are indeed apparent exceptions to the rule, as, for example, the stratified horny epithelium of the œsophagus, which is strikingly similar to the epidermis, although in one case the tissue is ectodermal, in the other entodermal. We have, however, to do only with a resemblance, and the development in the two cases is quite unlike—the œsophageal epithelium in the mammalian embryo being ciliated at one stage and exhibiting then little resemblance to any stage of the epidermis.

Each germ layer has its specific function, its exclusive share in the work of differentiation. The work of one layer is not done by another nor shared by another. It is true that attempts are made from time to time to upset the validity of this fundamental doctrine, but they have hitherto failed to find support or recognition from any leading embryologist, and I deem these attempts unworthy of serious consideration. We are able now to assign almost every cell of the normal adult human body to its proper germ layer. Our only great uncertainty is where two layers meet, as do the ectoderm and entoderm in the pharynx, or as do the mesoderm and entoderm, where the ureter opens into the bladder. With these and perhaps a very few other small exceptions everything in adult anatomy can be correctly stated in terms of germ layers. The layership of every organ is known, save that in the cases of the thymus gland, the tonsils and the adrenals authorities are not yet agreed.

A remarkable attempt to upset the doctrine of the germ layers deserves a brief consideration. It was first maintained by Goronovitch that the cells forming at least a part of the skeleton arose from the ectoderm. The same opinion was expressed also on the basis of their own investigations by H. Klaatsch and by Miss Platt. Confirmation of these views has not followed, but on the contrary, C. Rabl, one of the most trustworthy of living observers, maintains that essential parts of Goronovitch's and Klaatsch's evidence are simply errors of observation. Klaatsch's views were based partly on the study of the developing teleost fins. R. G. Harrison has shown that here the German worker is in error. Miss Platt's observations were made in the head region of embryo Necturus. An examination of a number of series and stages has not enabled me to find the slightest evidence in favor of Miss Platt's conclusions. H. K. Corning has pointed out that the processes alleged by Miss Platt to occur in Necturus do not take place in the frog, *Rana temporaria*. We may, therefore, I think, safely regard this attempt to overthrow the morphological value of the germ layers as unsuccessful. I know of no other attempt of sufficient importance to be even mentioned.

The importance to pathologists of a thorough knowledge of the genesis of the tissues from their germ layers can hardly be emphasized too strongly, for it is more than probable that all pathological tissues are as strictly governed by the law of the specific value of germ-layers as are the normal tissues. Are there not many pathologists whose knowledge of embryology is wholly insufficient to meet the practical needs of

their professional study even in this one direction?

The accompanying table presents the principal tissues classified according to their layership. There have been classifications of organs on the layership basis published before, but inasmuch as organs usually contain cells from two layers, we get a more correct presentation of the actual genetic relationships by restricting our tabulation to the tissues. Leucocytes do not appear in the table for the reason that their first origin is uncertain. Blood cells arise very early, before the clear separation of mesoderm and entoderm has occurred—it is possible that they are entodermal. With these two limitations, the table presents our present knowledge.

CLASSIFICATION OF THE TISSUES.

A. ECTODERMAL.	B. MESODERMAL.	C. ENTODERMAL.
1. *Epidermis.*	1. *Mesothelium.*	1. *Notochord.*
a. Epidermal appendages.	a. Epithelium of peritonæum, pericardium, pleura, urogenital organs.	2. *Epithelium* of
b. Lens of eye.	b. Striated muscles.	a. Digestive tract, œsophagus, stomach, liver, pancreas, small intestine, yolk-sack, large intestine, cæcum, vermix, rectum, Allantois (bladder).
2. *Epithelium* of	2. *Mesenchyma.*	b. Pharynx, Eustachian tube, Tonsils, Thymus, Parathyroids, Thyroid.
a. cornea.	a. Connective tissue, Smooth muscle, Pseudo-endothelium, Fat-cells, Pigment cells.	c. Respiratory tract, Larynx, Trachea, Lungs.
b. olfactory chamber.	b. Blood.	
c. auditory organ.	c. Blood vessels.	
d. mouth (oral glands), (enamel organ), (hypophysis).	d. Lymphatics.	
e. anus.	e. Spleen.	
f. chorion, Fœtal placenta.	f. Supporting tissues, cartilage, bone.	
g. amnion.	g. Marrow.	
3. *Nervous system.*		
a. Brain, optic nerve, retina.		
b. Spinal cord.		
c. Ganglia.		
d. Neuraxons.		

We will now turn to the analysis of the differential process in each germ layer. We have to deal with changes in cells.

There are two distinct types of cell differentiation, which I think have not hitherto been clearly recognized or defined. For both types the starting point is the same, the undifferentiated embryonic cell. In one type we find that as the cells proliferate, a portion of them only undergoes differentiation, and another portion remains more or less undifferentiated and retains more or less fully the power of continued proliferation. The epidermis is a good representative of this type. Its basal layer consists of embryonic cells, which multiply; some of these cells move into the upper layers, enlarge and differentiate themselves into horny cells; others remain in the basal layer and continue to multiply. The progeny of a given basal epidermal cell do not all have the same fate, but divide themselves into two kinds of cells, one kind retaining the ancestral character, the other becoming something new and unlike the parent cell. Differentiation according to the second type is characterized by its inclusion of all the cells. This type has its

culminating and most perfect illustration in the central nervous system, where comparatively early in embryonic life all the cells become specialized, and with the acquisition of specialization they forfeit their power of multiplication, the neuroglia cells partly, the nerve cells wholly. The growth of the brain after early stages depends not on proliferation of cells, but chiefly upon the increase in size of the individual cell. The correctness of this statement is not affected, in my belief, by the fact that epithelial portions of the medullary tube in comparatively late stages may be added to the nervous portion, the cells multiplying rapidly, as we see at the growing edge of the young cerebellum. The brain here grows by the addition of cells in the indifferent stage, but as soon as these cells are differentiated they conform to the general law and divide no more (neurones) or slowly (glia cells).

The two types of differentiation produce essentially unlike conditions. The pathologist may not overlook such unlikeness with impunity. The two types pass into one another with many intergrades. Hence when we consider the possibilities of pathological alteration we must in each case seek to determine how far the condition of the tissue involved permits cell multiplication, as well as differentiation.

Just as the segmentating ovum divides itself into parts, which we name germ layers, each of which has its special and exclusive share in developing the adult tissues, so does each of the three germ layers divide into parts, each part having its special and exclusive roll, and these parts again subdivide until, after the final partition, the adult variety is produced. During all these changes there is no exchange of rôles. It will be profitable to let the phenomena pass before us in rapid review.

First, then, the ectoderm. This layer early separates into two parts; one to form the central nervous system, the second the epidermis; the nervous part thereafter never forms epidermal structures, the epidermal part never forms a nervous system. The central nervous system retains in part a simple epithelial character, but most of its walls become nervous tissue; its cells pass from the indifferent stage and become neuroglia cells or young nerve cells (neuroblasts). Neuroglia cells never become anything else, and the nerve cells are always nerve cells to the end. The primitive epidermis forms a series of special sensory areas and the permanent epidermis. The sensory areas, which belong to the olfactory, auditory and gustatory organs, soon become well defined and never produce any cell arrangements like those of the epidermis. This last, on the contrary, remains as before stated, rich in undifferentiated cells, and gradually produces a great variety of structures. Most of these, namely, the hairs and glands, are small and very numerous, while a few like the nails, enamel organs and epithelium of the lips are larger. No one of these special structures, however, converts itself into another. The basal layer of the general epidermis may perhaps preserve a true embryonic quality and have wide differential possibilities.

Next, as to the entoderm, which undergoes less differentiation than either of the other two germ layers, since over a large part of its extent it remains throughout life a simple epithelium with many cells very slightly modified in structure. Wherever in it specialization takes place, as in the tonsil, thymus, thyroid, œsophagus, liver or pancreas, each territory of cells keeps its characteristics and never assumes those of another territory.

Finally as to the mesoderm, in which layer variety of differentiation attains its maximum. To follow the genesis of this variety is most instructive. The mesoderm

is found very early to include in vertebrate embryos, four kinds of cells, of which the most numerous are undifferentiated cells, the other three kinds being (1) endothelial cells of blood vessels; (2) blood cells; (3) sexual cells; all these are precociously specialized; they are few in number, yet they are probably the parents of all the cells which are produced of their kind throughout life. Our present knowledge does not permit us to speak with entire certainty, but the evidence is strongly in favor of the following three conceptions:

First. That all the endothelium of the blood vessels of the adult is descended directly from the endothelium of the first blood vessels differentiated in the extra-embryonic portion of the germinal area.

Second. That all the red blood corpuscles are descendants from the red-blood-cells of the blood-islands of the area vasculosa. According to this view the blood forming organs, as they are called, merely provide sites, where the red cells can multiply, as for instance in the mammalian embryonic liver or in the adult marrow.

Third. That the primitive sexual cells by their multiplication produce all the cells from which the genoblasts, or sexual elements proper, male and female, are evolved.

The future will decide the validity of these conceptions. They are very significant, because they assume that there are cells which form exclusive classes, and are characterized by a special combination of qualities, so that while they retain so much of the embryonic character as to have still the power of rapid multiplication, they yet are so specialized that they can only produce their like. If the three conceptions are established, we shall regard these three sorts of cells as almost the first to be fully differentiated. We shall also have to regard the vascular endothelium as distinct not only from the epithelial lining of the body cavity, but also from that of the lymphatic system. The immense importance of such a discovery as bearing upon pathological researches and interpretations is obvious.

The next important change in the mesoderm is the development of the main body-cavity, which the embryologist designates comprehensively as the cœlom. The cells, which lie next the body-cavity and border it, assume an epithelial arrangement; this epithelial layer around the cœlom is properly named '*mesothelium*,' and the loose cells about it constitute the '*mesenchyma*.' We do not have, however, at first a true differentiation of mesothelial and mesenchymal cells; all are undifferentiated, and we can readily demonstrate that the cells are interchangeable, differing during early stages by their positions in relation to one another and to the body cavity, but not differing in their essential structures or qualities. Thus we find that the mesothelium constantly gives off cells which join the mesenchyma, and we find later that mesenchymal cells may take on an epithelial arrangement around any of the cavities—and there are many such—which arise within the mesenchyma itself in the course of further development.

But, although difference of arrangement does not necessarily indicate differentiation of the cells, it does affect the character of the differentiation which ensues. As every text-book states, the mesothelium gives rise to the striated muscles and to the epithelial portions of the entire genito-urinary tract, and is permanently retained, with slighter modifications, as the epithelium of the pericardium, pleuræ and peritoneum. The mesenchyma produces an even greater variety since it is the parent of not only all the connective and supporting tissue, but also of the lymphatic system.

I venture to turn aside for a moment to urge upon you the adoption of the term mesothelium as the correct designation for the

epithelial lining for the cavities of the thorax and abdomen. It is literally the same epithelium in the four cavities, for they were originally one, with a single continuous epithelium. It is well also in our nomenclature to recognize the important fact that the epithelium is radically, because genetically, distinct from the endothelium of the blood vessels and lymphatics, and the application of the term 'endothelium' to the covering of, for instance, the peritoneum, leads and can lead only to confused bad thinking. If mesothelium be employed as suggested, clearness will be gained.

Coming back now to the subject of the mesoderm, let us note that when a striated muscle fiber is produced a striated muscle fiber it always remains, and it never becomes anything else; the ovary never changes. In short, with the mesoderm as with the ectoderm and entoderm, we see the fate of the cells once fixed to be thereafter unchangeable as to the kind of differentiation.

Our hasty review is worse than imperfect, yet is sufficient to impress upon us the great law that differentiation in any direction terminates the possibility of differentiation in any other direction. In accordance with this law we encounter no instances, either in normal or in pathological development, of the transformation of a cell of one kind of tissue into a cell of another kind of tissue, and further we encounter no instance of a differentiated cell being transformed back into an undifferentiated cell of the embryonic type with varied potentialities.

Thus far I have expressed myself somewhat as if there were two sharply defined conditions, the differentiated and the undifferentiated. To give such an impression would be to create error, since differentiation is a slowly progressive and wholly gradual change in the cell. We must look upon each step in the process of differentiation as establishing narrower limits for future changes. Thus, when in the spinal cord neuroblasts diverge from the glia cells, they are not specialized into different classes of neuroblasts; such specialization comes later. So in the mesenchyma after the embryonic cells have changed and large numbers of them have become connective tissue cells, these last still are capable of various further differentiations, and may, therefore, be said to have been arrested in their development at a stage of partial differentiation. This quality of the connective tissue cells is, from the pathological standpoint, one of the most important facts known to us concerning the structure of the body.

Having now elaborated, as far as time permits, our conception of the nature of differentiation, let us turn to our third fundamental idea, which concerns the changes which succeed differentiation. These changes are very unlike the constructive changes which precede them, for they are destructive. They fall into three main groups:

1. Changes of direct cell death.

2. Necrobiosis,* or indirect cell death preceded by changes in cell structure.

3. Hypertrophic degeneration or indirect cell death preceded by growth and structural change of the cell.

Of direct cell death no discussion is here necessary, for the fundamental idea, which I wish to emphasize, is that necrobiosis and hypertrophic degeneration are normal processes, which invariably occur in the normal body and play in many cases important rôles in the life history of the individual. Without necrobiosis and degeneration on a large scale, the normal round of human life would be impossible. It is singular that in treatises on normal anatomy and

* It is a matter for regret that so awkward a term as 'necrobiosis' should have become current.

histology these two subjects are generally neglected or at most appear only as matters of incidental reference. The force of tradition makes us apply these terms as if they correspond exclusively to pathological conditions. This tradition might still prescribe our mental attitude, were it not that the studies of the last dozen years have made us familiar with the enormous extent, variety and rapidity of the destructive degenerations which go on in the pregnant uterus of placental mammals, a degeneration which takes place without affording a trace or a suggestion of any pathological modification whatsoever of the organ. To our inherited prejudices the uterine phenomena alluded to are startling, but their evidence before the tribunal of biology has settled the case in favor of the plea that hypertrophic degeneration is a normal factor in typical healthy development.

The normal and pathological changes associated with the death of cells, and consequently also of the tissues which are formed by cells, are so nearly identical that they may be combined in a single discussion. For the more convenient presentation of the subject the following table has been prepared. Concerning the table little explanation is necessary.

A few special points need mention. The distinction made between necrobiosis and degeneration corresponds to recognizable differences, but our present knowledge is insufficient to provide clear definitions for the two closely related types of indirect cell death. I feel much doubt as to the propriety of including *atrophy* in the table at all, since it seems to me that we ought, perhaps, not to regard atrophy as a phenomenon of a distinct class, but merely as a result of necrobiotic or degenerative alterations in cells and organs. Under the heading 'degeneration' the division into 'cytoplasmic' and 'paraplasmic' takes us beyond our present knowledge, while the division 'nuclear' is added rather to satisfy a biological conscience than to represent a part of our knowledge.

Death of Cells.

First—Causes of death.
- a. External to the organism.
  - 1. Physical (mechanical, chemical, thermal, etc.).
  - 2. Parasites.
- b. Changes in intercellular substances (probably primarily due to cells).
  - 1. Hypertrophy.
  - 2. Induration.
  - 3. Calcification.
  - 4. Amyloid degeneration.
- c. Changes inherent in cells.

Second—Morphological changes of dying cells.
- a. Direct death of cells.
  - 1. Atrophy.
  - 2. Disintegration and resorption.
- b. Indirect death of cells.
  - 1. Necrobiosis (structural change precedes final death).
  - 2. Hypertrophic degeneration (growth and structural change often with nuclear proliferation precede final death).

Third—Removal of cells.
- a. By mechanical means (sloughing or shedding).
- b. By chemical means (solution).
- c. By phagocytes.

The preceding table represents the only attempt of the kind known to me, and like other first attempts is undoubtedly very imperfect. It embodies obviously no new facts. But, because it is frequently a scientific gain to systematize our information, I hope the table may be useful, and it will certainly serve its immediate purpose, namely, to guide our discussion of the normal changes which follow after cellular differentiation.

As the time at our command is brief let us pass by the consideration of the causes of cell death. I will remark only that I think amyloid degeneration may be found to occur in the placental decidua of the human pregnant uterus and perhaps in other normal structures. No positive information

on this point is known to me. For the reasons stated a few minutes ago atrophy may also be omitted here. We pass by also the direct forms of cell death, to reach at once the consideration of the indirect forms.

The accompanying table offers an analysis of some of the principal varieties of structural change, which occur during indirect cell death.

Indirect Death of Cells.

A. *Necrobiosis.*
   1. Cytoplasmic changes.
      a. granulation.
      b. hyaline transformation.
      c. imbibition.
      d. desiccation.
      e. clasmatosis.
   2. Nuclear changes.
      a. karyorhexis.
      b. karyolysis.

B. *Hypertrophic degeneration.*
   1. Cytoplasmic.*
      a. granular.
      b. cornifying.
      c. hyaline.
   2. Paraplasmic.*
      a. fatty.
      b. pigmentary.
      c. mucoid.
      d. colloid, etc.
   3. Nuclear (? increase of chromatine).

We begin, therefore, with necrobiosis. We may appropriately mention first those organs of which the existence is limited in time, such as the thymus and the fœtal kidney (mesonephros or Wolffian body). These organs attain first their full differentiation; their elements during the next phase die off, and finally are resorbed, most of the organ disappearing. In the same category of change belong the histories of the senile ovary and testis. Another familiar illustration is offered by the notochord, which in the mammals totally disappears during the fœtal period. The notochord cells undergo peculiar characteristic modifications, hence it is difficult to say whether or not there is degeneration in the strict sense. Cell-death on a large scale is a common phenomenon of the tissues. It occurs in cartilage both when the cartilage is permanent and even more conspicuously when cartilage gives way to bone, the disintegration of the cartilage cells preceding the irruption of the bone forming tissues. It occurs among the bone cells after they are imbedded in their calcified matrix. It occurs in the ovary, where we designate its result as atresia of the follicles. It occurs in the sebaceous glands as an accompaniment of the process of their secretion. It occurs among the glands of the intestine as discovered by Stöhr, and occurs normally, though not constantly, in the appendix, as recorded by Ribbert. It occurs in the epithelium of the human pregnant uterus and in all the tissues of the human decidua reflexa. Other examples could be enumerated, but we may content ourselves with citing the constant destruction of blood corpuscles, both red and white.

Degeneration, in the stricter sense of an ante-mortem hypertrophic change of cell structure, is also of widespread occurrence in the healthy body. No case of so-called granular degeneration under strictly normal conditions is known to me, though it seems quite credible that such cases should occur. On the other hand, the cornifying degeneration is very important and does occur in all three germ-layers, for we observe it in the ectoderm of the skin, the entoderm of the œsophagus and the mesoderm of the vagina. Hyaline degeneration of so striking a character as to have been termed pseudo-pathologicial takes place regularly in the ectoderm (outer epithelium) of the placental chorion. In the rabbit it occurs in the uterine glands, during pregnancy, causing most rapid histolysis, and it seems to me probable that some of the changes, which can be observed in the decidua of the pregnant human uterus

* I cannot venture to assert that these two divisions are valid, and not arbitrary.

ought also to be regarded as cases of hyaline degeneration. That fatty degeneration takes place normally has long been taught. There seems no reason for regarding the development of ordinary or mesenchymal fat-cells otherwise than as instances of normal degeneration. In old age a more or less marked fatty degeneration may be wide spread and occur in many different kinds of cells. The same is true of the deposit of pigment, as we see it in the liver cells and motor nerve cells of adults. Finally, mucoid and colloid degeneration are so obviously normal, that we commonly think of their pathological occurrence as merely an exaggeration of a normal state.

The various kinds of changes in dying cells, with which the pathologist is most familiar, recur in healthy tissues. In the preceding table seven forms of change are enumerated under the heading '*necrobiosis*.' Every one of these seven occurs normally. Granulation of the bodies of the cartilage cells and of the notochord cells may be observed to precede their resorption. Hyaline transformation is conspicuous in the decidua reflexa. Imbibition or cellular œdema occurs in the epidermis of the lips, in the cells of the uterine glands during pregnancy after they have detached themselves from the gland walls, and in the endothelium of placental blood vessels of the rabbit. Desiccation is the usual accompaniment of cornification. Clasmatosis has given its name to the clasmatocytes of Ranvier, and we may well apply the same term to the cells of the secreting milk gland, and also, as an unpublished research indicates, to the cells of the secreting glands of the cervix uteri. Karyolysis is, according to present probabilities, the method by which nucleated red blood cells are converted into non-nucleated blood-corpuscles. Karyorhexis, or the fragmentation of the nucleus, occurs in the cells of the disappearing follicles of the ovary.

Lastly as to the removal of cells. The sloughing off of cells is one of the most familiar phenomena, since it occurs incessantly over the epidermis and with the hairs; its part in menstruation and its colossal rôle in the afterbirth are known to all, and every practitioner is accustomed to look for shed cells in urinary sediment. Large numbers of cells are lost by the intestinal epithelium. Cells without access to the external world must be got rid of by resorption, which seems to take place either with or without the cooperation of leucocytes. In the latter case we must for lack of a better hypothesis attribute the resorption to chemical means. Of resorption with the aid of leucocytes the necrosed human decidua reflexa offers a perfect illustration. Of resorption without leucocytes the masses of degenerated epithelium in the placenta, periplacenta and obplacenta of the rabbit afford by far the most impressive demonstration I have ever seen. At nine days after conception the epithelium is profoundly changed, being very much thickened, and where thickened transformed into a syncytium without cell boundaries, but with an enormously increased number of nuclei. In the obplacenta (or portion of the uterine wall opposite the placenta proper) portions of the epithelium from the fundus of the glands remain, but the upper stratum has not only undergone syncytial degeneration, but has become vacuolated and partly resorbed without being directly attacked by either leucocytes or epithelium or any other kind of cells. At eleven days the resorption has progressed still farther, so that the degenerated part is almost gone, but meanwhile the isolated patches of epithelium have spread until they have united and so reformed a continuous epithelium. At thirteen days the epithelium has reconstituted new glands or follicles, very unlike, however, those of the resting uterus. To ex-

plain the extraordinarily rapid disappearance of the degenerated material in the obplacenta the only available hypothesis seems to be that of a chemical change by which the material becomes soluble or is dissolved, for we see the disappearance of the substance taking place in the very heart of the layer, and not merely at the surface. Sloughing is impossible and there are no phagocytes, leaving the chemical explanation as the only one I have been able to conceive. The contemplation of the described phenomena of the rabbit's obplacenta inevitably raises the question—do we not tend in our explanations of the removal of necrosed and degenerated tissues to attribute too much to phagocytes and too little to direct chemical action? May it not be that the body produces histolytic toxins, which can destroy tissues somewhat as do snake-poisons?

The cycle of changes through which cells pass is obviously longer than the period of development and the differentiation, yet its phases all belong together as members of a single series. We lack a word to designate the entire series of changes, and for the lack of such a word often fail to appreciate the essential unity of progressive and regressive modification of cell-structure. Accordingly, I wish to propose the new term *cytomorphosis* to designate comprehensively all the structural alterations which cells, or successive generations of cells, may undergo from the earliest undifferentiated stage to their final destruction.

PART II. PATHOLOGICAL DIFFERENTIATION.

We have now completed our brief reviews of the four fundamental successive stages of cytomorphosis. These stages are:

First .Undifferentiated.

Second. Progressive differentiation, which itself often comprises many successive stages.

Third. Regression (necrobiosis or degeneration).

Fourth. Removal of the dead material.

Let us now apply some of the conceptions won to the interpretation of pathological differentiation, remembering all the time that the interpretation of disease is a distinct and different problem. Although presumably pathological differentiation is the sole and exclusive cause of disease and no disease arises from any other immediate cause, yet the disease must be regarded as the result and, owing to the physiological correlation of the organs, this result may include many secondary effects, some of which are often of the greatest diagnostic value, and therefore likely to divert attention from the primary structural cause.

Our review of normal conditions furnishes us with three general conceptions, which are valuable for their pathological applications,—namely:

First. That each germ layer has a specific and exclusive share in the production of tissues.

Second. That undifferentiated cells, characterized by having only a small amount of unspecialized protoplasm, exist not only in the embryo, but also throughout life in certain parts of all three germ-layers.

Third. That differentiated cells characterized by having a larger amount of specialized protoplasm, form most of the organs of the adult and are incapable of undergoing any new unlike differentiation, though they are still capable of completing their cytomorphosis, by necrobiosis or degeneration.

We must apply these conceptions, according to my belief, as rigidly to pathological as to normal development. Thus, as to the germ-layers, it ought to be possible even with our present knowledge, to show their pathogenetic values, so that every elementary student as a matter of course can be taught to classify accurately most pathological differentiations, and to accept such

a classification as the basis of all his further study of the science. How much this reform is needed is indicated by the many writers who put glioma under the head of connective tissue tumors, although gliomata arise from the ectoderm, and connective tissue arises from the mesoderm. Such a classification is on a par with the ancient system which put the whales among the fish, for it is not going too far to say that it is impossible that connective tissue should produce a glioma, because the two things belong in different classes. Another noteworthy violation of embryological law is offered by the classification of all muscle-tumors under one head, '*myoma*,' although smooth and striated muscle fibers are genetically and structurally distinct, with no intermediate or connecting forms of tissue, and with only a slight physiological resemblance. As regards epitheliomata; they should be studied in relation to their layership, and it is reasonable, in my judgment, to expect that they will be found to have very distinctive characteristics according to the germ-layer from which they take origin, for the layership of a tissue governs the normal differentiation and therefore probably also the abnormal. I believe that the first competent investigation in this field will mark a new epoch of pathological science. When the epoch comes our morphological sense will no longer be shocked, as for instance by the application of the name adenoma to an epithelioma of an organ like the kidney, which is in no sense a gland.

I should like to urge especially the study of the layership of the various cancers. Can we safely assume that there is only one kind of cancer? May it not well be that ectodermal, mesothelial and entodermal cancers are separate kinds?

Next as to undifferentiated cells. The cells of this sort have the power of multiplication in a high degree, and they have the possibilities of increasing their size and of undergoing further differentiation, and their occurrence in the adult is of the utmost pathological significance. Such cells exist in four important parts, (1) in the basal layer of the epidermis and in corresponding portions of the epidermal appendages; (2) in the adult mesenchyma or connective tissue; (3)in many parts of the adult mesothelium, especially of the epithelia of the genito-urinary tracts; (4) in the entodermal epithelium of the gastro-intestinal tract. It is significant that it is precisely from these parts that the development of many rapidly growing tumors takes place, and it is further significant that the least differentiated or specialized of all, namely, the mesenchymal cells, are the ones which produce the greatest variety of tumors—as the following list recalls: myxoma, myoma (but not rhabdomyoma), fibroma, lipoma, chondroma, osteoma and sarcoma. Angioma presumably belongs in a different category. The mesenchyma still exhibits, by the formation of its characteristic tumors in the adult, its embryonic capacity to transform itself in varied ways.

Further insight into pathological development may be gained from the tissues or cells which have undergone differentiation, but do not attain a high grade of specialization. The endothelium of blood-vessels, the endothelium of lymph-vessels, the red-blood cells, the leucocytes and the neuroglia are examples of this class. All the cells of the kind just enumerated have advanced in organization beyond the embryonic state, but have retained the power of cell multiplication. When they multiply they produce cells like themselves, so that we might describe them as so many histological species each capable of reproducing its own kind. In accordance with this conception, derived from the normal development, is the pathological fact that each of these

species of cells produces tumors of its own kind. This is a familiar conclusion as regards the endothelium, both of the blood-vessels and of the lymph-vessels, and also as regards the neuroglia. It seems to me that the excessive multiplication of leucocytes may properly be classed in the same category as the growths resulting in angioma and glioma. I do not know whether or not an excessive and abnormally rapid production of red blood cells may occur so as to occasion a special and distinct disease. Increased production of red blood cells (erythrocytes) is, of course, well known to occur, but I understand that a distinct disease of this origin is, as yet at least, not recognized. It is not improbable, however, that such a disease exists—we should, I suppose, name it *erythrocytosis* or *haematoma*.

We can now distinguish two main groups of new formations; first, those with marked cytomorphosis, or changes in cell structure, as, for example, myoma, lipoma, chondroma, etc.; second, those without marked cytomorphosis, the cells of the new growth resembling those of the parent tissue as, for example, angioma and glioma.

Members of the first group have been termed *heteroplastic*.

Members of the second group have been termed *homoplastic*.

Accepting these terms, we may say tumors are either *heteroplastic* or *homoplastic*. From the standpoint of the embryologist these terms are much more than convenient adjectives; on the contrary, they denote differences of a fundamental character, upon which we must base a large part of our notions about pathological differentiation.

Finally, as to the differentiated cells. We have just considered cells which have reached a low degree of differentiation, and therefore will now give our attention only to the most highly differentiated. Of these the nerve cells, or as they are now termed, the neurones, stand highest and are characterized not only by the great specialization of their organization, but also by the complete loss of their ability to multiply by cell-division. The neurones are then extremely unlike the embryonic cells and they represent the extreme end of that scale of which the undifferentiated cell is the beginning. It is, therefore, very significant that neurones do not form tumors. Neuronoma, as such a tumor would be called, does not occur, so far as hitherto recorded—and if, as is possible, a neuronoma should be found, we should have to explain it not as a tumor-growth of neurones, but as the result of proliferation of indifferent cells, which subsequently became differentiated into neurones. The so-called neuromata of pathologists do not here come into consideration because they are merely accumulations of growing axis-cylinders.

Liver cells and striated muscles also represent a very high differentiation. It is possible that with more exact knowledge we shall be able to state that these elements also cannot produce tumors, although there may be tumors of the liver and of striated muscle-fibers. Possible, because Cohnheim's famous theory of tumor origin from persistent embryonic tissue may be, though not generally applicable, available in these two instances. The adoption of this view would furnish an explanation of several familiar facts; of the fact that we do not find tumors formed by differentiated liver cells; of the fact that cancer of the liver arises usually from the bile-ducts, which have a simple and little differentiated epithelium; of the fact that myoma of the cardiac and of the developed skeletal muscles is exceedingly rare; of the fact that rhabdomyomas so occur that their origin may be attributed to inclusions of portions of embryonic muscle plates. As regards primary epithelioma of the liver, it is claimed that it arises usually from the bile-

ducts, but the liver-cells are also involved, but how it comes about that the liver-cells participate is, so far as I have been able to learn, by no means clear. From analogy with other tissues, we infer that it is improbable that the large and specialized liver-cells ever resume an embryonic character. In short, I deem our understanding of the pathological differentiation of hepatic cells and of striated muscle fibers too imperfect to support a judgment. We can only say that the rarity of such differentiation concords with the degree of normal specialization of the cells and fibers in question.

Our very brief discussion of pathological differentiation seems to justify the following conclusions: *First*, the process in its essential features is identical with the process of normal differentiation; *second*, the character of a tumor depends primarily upon the layership of the cells producing it; *third*, normal differentiation impedes and limits the formation of tumors, precisely as it does of further normal structures; so that tumors arise most readily from undifferentiated tissues and may then be heteroplastic; and arise readily from differentiated tissues and are then always homoplastic; and arise unreadily or not at all from the most highly specialized tissues.

Each of these three conclusions might be advanced as a law of normal development, if we substitute the term 'differentiated tissue' for 'tumor.'

We now pass on to the final stage of cytomorphosis, necrobiosis and hypertrophic degeneration in their pathological manifestations. The consideration of the direct or simple death of cells need not detain us, nor need we pause long over the indirect forms of cell death. In fact, the analysis made earlier this evening of normal necrobiosis and degeneration forced us to recognize that all, or nearly all, the modes of indirect cell death which the pathologist encounters in morbid tissue recur under healthy normal conditions. To put the conclusion in its correct form, we need only to reverse it, saying:

Most, and probably all, pathological necrobiosis and degenerations of cells are essentially identical with normal processes, and are pathological, owing to the abnormality of their occurrence in time and site.

Death of a cell may, of course, occur at any moment as a consequence of conditions external to itself. To a given cell, as such, it is of no moment whether the term 'physiological' or 'pathological' be applied by us to the conditions which cause its death. The cell has its own inherent qualities, and its own cytomorphic possibilities. All that the environment of the cell can do, so far as we can at present understand, is to evoke, and perhaps to a minor degree modify, one of the possible structural changes of the cell. Hence we find actually that the processes of cellular necrobiosis appear to us identical in normal and pathological cases. This affirmation does not imply that a given cell has only one kind of possible necrobiosis before it. Quite otherwise, it being reasonable to believe that any one of several forms of necrobiosis, according to the circumstances, may ensue.

All that has just been said might be repeated in reference to hypertrophic degeneration. One of the investigations which is most needed at the present time, and which promises results of extreme interest and importance, is the investigation of necrobiotic and degenerative cytomorphosis, carried out as a research upon cell structure. At present we cannot discuss the subject except in terms the very vagueness of which is a mortifying confession of ignorance.

Time forbids the prolongation of the discussion. But, although a more detailed study is thus for the present excluded, we

have, nevertheless, dealt with the subject with sufficient fullness, I hope, to convince you, if you were not already convinced, that the fundamental problems of pathology and embryology are alike, not only in being problems of cell life, but also in being similar and even identical problems of cell life. Widely as the two sciences differ, they rest on a common foundation.

To complete our subject it would be necessary to summarize our present knowledge as to the causes of cell differentiation. Physiological morphology is a new science; we have barely crossed its threshhold, and are not yet at home in it. To the physician this new science promises to far surpass in practical importance even the bacteriology of our time, since it is not presumptuous to hope that when we understand the physiological factors, thermal, chemical stimulant, mechanical and other, which bring about structure, which cause cytomorphosis, we can acquire control over cellular differentiation, and ultimately be able to prevent some of the most formidable diseases, over which we now have little or no power. The diseases which we may attack in the future in this way are diseases which may be designated as morphogenetic, because they are due to errors of morphological differentiation. At this vast topic it is impossible now to more than hint.

Here we may stop, not because all the great host of relations between embryology and pathology have been marshaled before us, but because enough of these relations have passed us in review to present a conclusive body of arguments. As we follow their march, we find ourselves led to the attack upon the problem of the causes of the specialization of cells, of histogenesis. To conquer this problem our only hope lies in the junction of all our forces.

Before closing, a personal word: first, of sincere thanks for the honor you have conferred upon me both by your invitation and by your attention, and then a word to express the great diffidence with which I have undertaken to deal with pathological phenomena. A man of science ranks according to the number of details which he has mastered, and his ability to drill them into coherent battalions. By no such system of ranking can I hope to be included among pathologists. I offer, therefore, only the thoughts of an outsider, derived from the long pursuit of a cognate science. Such external suggestions, being independent to some degree of pathological tradition, may contribute to vivify the conception of the unity of the biological phenomena and, therefore, of all forms of biological investigation. It will be a service rendered if my words recall the great truth that biology is not a congery of sciences, but a single science, which we artificially divide and subdivide until the parts are commensurate with our mental capacity. In the truest sense we are fellow-workers. Let us, therefore, work together.

Charles Sedgwick Minot.

THE DETERMINATION OF THE TYPE IN COMPOSITE GENERA OF ANIMALS AND PLANTS.

To the older naturalists a genus was a subdivision of an order containing a number of species, each standing in like relations to the genus. The genus was a pigeon-hole into which species of similar characters were thrust.

In the modern conception a genus is a group of related species, associated about a single one which is the type of the genus. In theory this type should be the central species or the most primitive one. In the exigencies of nomenclature, it is the one which was in point of fact first associated with the generic name. Modern writers recognize this grouping of species about the generic type, and to each new genus of

most recent writers a type is definitely assigned by the author of the genus. In modern rules of nomenclature the definition of a genus may be altered or even reversed, but the generic name must adhere to the original type.

The most serious difficulty in connection with the matter of nomenclature lies in the reduction of the ancient conception of the genus to the terms of the modern one. It lies in the assignment of a type species to a group in which the original author had no conception of the need of such a species.

In the subdivision and fixation of the ancient genera, various methods have been followed, with varying results. In other words, these methods have lacked the one important element of inevitableness. A rule of nomenclature has little value unless it lies in the nature of things. If it is artificial, it will be discarded.

In general, three methods have been followed in fixing the types of the early composite genera:

1. To follow the arrangement of the author who first subdivides the genus subsequent to the work of the original author.

In this many difficulties have been found in practise. The first restriction is often in obscure publications. It is often obscurely done. In other words, a genus is often subdivided in such a way as to leave no clear idea as to what the author would leave in the original group. Sometimes he leaves nothing at all, as in the case of the Linnæan genus, *Sparus*, for which no place was left after its subdivision. As a matter of fact, this system leaves the proper application of many generic names in doubt, and necessitates a profitless investigation of the opinions of early authors who wished to improve Linnæan nomenclature, but who worked on too small a scale to accomplish much.

A second system derived from this is the method of elimination. The genus of the eighteenth century corresponds roughly to the family of the nineteenth. The family may contain several genera. These may be withdrawn from the original genus in chronological order, and the old name left with the final residue. But this residue will generally consist of foreign species or species unidentified or unidentifiable. To meet this difficulty the method of elimination in birds has been applied to European species only, that generic names based primarily on European forms may not be forced out of the European fauna. To make the system workable a variety of other minor rules must be invented, as a little change in the point of view as to some obscure author will make an entire change in the final result. The final result is the only matter of interest.

The ornithologists have found this scheme workable and it is incorporated in the rules of the American Ornithologists' Union. But even here it has not yielded stability of nomenclature, as several generic names (as of owls, loons) have been more than once altered in obedience to its dictates. But in American ornithology any rule has the great advantage of the imposition of authority. The ornithologists of America agree to stand by their committees, and any decision these may make is final for them and their associates, that is for most ornithological work in America for the present generation.

Other branches of science have no such authority behind their verdicts, and without it the determination of generic types by elimination is a failure. Often two men working independently cannot reach by the same rules an identical result. It is not always easy for the same man to reach the same result twice.

Let us take a concrete problem. The genus *Clupanodon* of Lacépède (1802) containing those herrings which have no teeth includes several modern genera.

It was based originally on six species, *thrissa*, *nasica*, *pilchardus*, *sinensis*, *africanus*, *jussieu*.

In 1810, Rafinesque proposed to substitute *Thrissa* for *Clupanodon*, presumably because the latter name is badly formed. Presumably again, *thrissa* would be the type of this genus of Rafinesque, who again presumably took it, as the first species mentioned, as the type of *Clupanodon*.

In 1820, Rafinesque founded the American genus, *Dorosoma* (Chatoëssus), and to this genus *nasicus*, and afterwards *thrissa* were referred; *pilchardus* was long left in *Clupea*, which is older than *Clupanodon*, but in 1860 a related species (*pseudohispanicus*) became the type of the genus *Sardinia* of Poey. *Africanus* has teeth and does not conform to the definition of *Clupanodon*. It was made, in 1839, the type of a genus *Platygaster*, Swainson, but this name is preoccupied. Afterwards *Ilisha* (Gray, 1846) and *Pellona* (Valenciennes, 1847) were based on a species of the same type, the former without definition. *Sinensis* and *jussieu* were placed, in 1847, in a genus *Clupeonia*, by Valenciennes. Finally in 1900, Jordan and Snyder established the genus *Konosirus* on a Japanese species (*punctatus*) which proves identical with *thrissa*, and to which group *nasicus* also belongs.

In their first consideration of this generic name, Jordan and Gilbert succeeded in convincing themselves that *Clupanodon* should take the place of *Clupeonia*. Eliminating *Pellona*, and the earlier names *Dorosoma* and *Clupea*, *Clupanodon* was left for the remaining species, *sinensis* and *jussieu*.

But in 1896, Jordan and Evermann recognized that if *Sardinia* were a distinct genus, the rule of elimination required them to transfer to it the name *Clupanodon*, as *Sardinia* is of later date than *Clupeonia*.

In 1900, Jordan and Snyder showed that *Dorosoma punctatus* was the type of a distinct genus, which they called *Konosirus*. Later it became evident that *thrissa* was identical with *punctatus* and by the law of elimination the name *Clupanodon* must supersede *Konosirus* as *thrissa* was the last of its species to be removed to a genus of its own. By this system the old generic name can never come to rest, but must be held in readiness to replace any new genus which may be formed from species included in its original content.

It was possible to defend in turn the use of *Clupanodon* in place of *Clupeonia*, *Sardinia*, and *Konosirus*. Should *nasica* ever receive a distinct generic name, *Clupanodon* must again move forward to replace it. On the other hand, writers called 'conservative' will reunite *Konosirus* with *Dorosoma* and *Sardinia* and *Clupeonia* with *Clupea*. In such case *Clupeonia* must fall back on *Ilisha*, a group originally included in *Clupanodon* by error. It is evident, that in this case no fixity is possible by the method of elimination, unless imposed by the temporary authority of some ichthyological union or mutual agreement among writers.

In default of such the present writer will use *Clupanodon* in place of his own genus, *Konosirus*, not on account of the results of elimination, but because the type of *Konosirus* is the first species named by Lacépède under his account of *Clupanodon*. If he should grow more 'conservative' he might reunite *Clupanodon* with *Dorosoma*. In such case he would call the whole genus, *Clupanodon*, because the name is prior to *Dorosoma*.

The third method of determination of generic type is through consideration of the work of the author of the genus in question, without regard to the views or work of any subsequent matter.

This we do in accepting as the type of a genus the species indicated as such by the author. Such a statement cannot be reversed by any later author. In recent days, the type of a genus usually is indicated once for all in so many words. With earlier

writers who did not take this method we may be allowed to read between the lines. A leading ornithologist (Alfred Newton, if I am not mistaken), suggests that in the case of Linnæus we be allowed to ask the author what type he would have chosen if the modern problem were to be presented to him. As to this we should not be often left in doubt. If we are in doubt however, there is a very simple rule followed widely by naturalists, notably by Bleeker, the most voluminous writer on fishes. This is the selection, as type, of the first species named under the genus by its author, when other indications fail. This rule gives fixity, the sole essential thing. It gives justice. It saves a profitless overhauling of bibliography, and it is a clear way out of confusion. It is the only possible clear way.

I suggest for consideration the following provisional rules for the application of this method:

1. The type of a genus is the species designated as such by its author.

2. If no type is designated by the author, either explicitly or by clear implication, then the first species referred to the genus or the species standing first on the page, shall be considered as its type. A generic name should have no standing, if resting on definition alone, nor until associated with some definite species.

3. To this rule the following provisional exceptions may be made. The type of each genus of Linnæus as stated by him is 'the best known European or officinal species' it contains. In case of doubt in the application of this rule, the species standing first may have the benefit of the doubt. Unlike most subsequent authors, Linnæus usually placed his type species near the middle in the list of species. Cuvier made it his 'chef de file.'

4. In case of genera based on old specific names (*Belone*, *Achirus*, *Trachurus*) the species thus furnishing the name, if actually mentioned by the author of the genus, may be regarded as its type.

5. Possibly, to avoid confusion, it may be well to retain old generic names, restricted by common consent to a species not the first mentioned by the author, provided that such restriction antedates any modern names for the same genus. Thus it may be well to retain *Centropomus* for *Oxylabrax*, instead of *Lucioperca*, *Cheilodipterus* for *Paramia*, instead of *Pomatomus*, *Pomacanthus*, for *Pomacanthodes*, instead of *Zanclus*. But I doubt the wisdom of this exception, and I shall not be surprised to see future writers following Bleeker in the use of *Oxylabrax* and *Paramia*, leaving the generic names of Lacépède and of all writers since Linnæus, to the first species named by their author.

DAVID STARR JORDAN.

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*NOTE ON THE NUMBER OF PARTICLES IN THE SATURATED PHOSPHORUS EMANATION.**

IN a series of experiments made by passing air ionized to saturation by phosphorus through a slender tubular condenser (60 cm. long, radii of air space, .30 cm. and .16 cm.), I showed that the electrical current radially through the condenser for a given potential difference, and the volume per minute of the ionized air sent longitudinally through it, were rigorously proportional quantities. At the same time the color of the steam tube observed on passing the air from the condenser into it, was invariable no matter whether the condenser was charged or not, *cæt. par.* Hence only an insignificant part of the particles producing condensation takes part in the electric current even with radial fields of 2,100 volts per cm., the highest safely admissible. I have estimated that less than 5 per cent. of

* Preceding experiments in SCIENCE, Feb. 9, 1900, the above note being a sequel. I there gave relative values for the absorption velocities, absolute values being given in the *Am. Journ. of Science*, March, 1900.

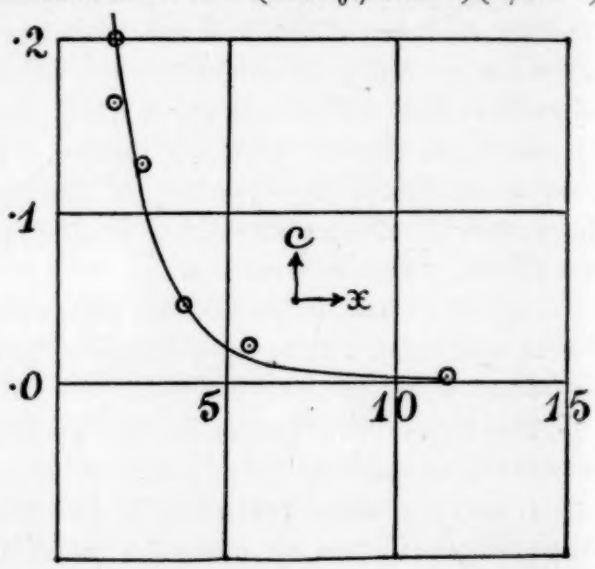
the ions could have been destroyed by the electric transfer; otherwise the steam tube would have shown perceptible variation of color.

In connection with this result I have questioned whether the importance of the mutual destruction or decay of the ions has not been overestimated; whether the phenomenon of leakage in a plate condenser may not be very fully explained * by taking account of the ions which wander *laterally* out of the field of force. Let A be the area of the condenser of air space x, and let ax be the circumferential area terminating in the edges of the condenser (mantel of the cylinder of air). If one of the plates is a phosphorus grid (thin pellets of phosphorus secured between appressed discs of wire gauze), let n be the number of particles per cubic centimeter at a normal distance x from the grid. Let k be the (absorption) velocity of the ions in the absence of an electrical field when passing from a saturated region either into free air or normally to an absorbing surface, and $k'n^2$ the number decaying per cubic centimeter per second.

Remembering that in such a condenser there is lateral loss of ions escaping from between the plates, as well as the loss upon the plates whether the (phosphorus) condenser be charged electrically or not, the differential equation meeting the case is $-dn/dx = n(a/A + nk'/k)$. This is integrable in finite form, and if n_0 be the number of ions per cubic centimeter at the phosphorus plate (saturation), the equation becomes $n/n_0 = (a/A)/((a/A + n_0k'/k)\varepsilon^{(a/A)x} - n_0k'/k)$. If $k' = 0$, decay within the ionized space is ignored and $n = n_0/\varepsilon^{ax/A}$. Thus n is independent of the absorption velocity k, depending for a given initial saturation n_0 only upon the mantel (ax) and the base (A) areas of the condenser air space.

Now let the condenser be charged, remembering that the additional loss from this cause alone is insignificant. Let V be the potential difference at the time t, C the effective capacity, U the relative or mutual velocity of the ions, e the charge of each. Then $-dV/dt = AUVne/Cx$, or from the value of n, $-dV/dt = (AUVn_0e/C)/x\varepsilon^{ax/A}$.

In my data given in the *Physical Review* (l. c., Table III.) I put, as usual for leakages, $V = V_0 10^{-ct}$, whence c was computed. Substituting this in the preceding equation, it reduces to $c = (AUn_0e/Cln10)(1/x\varepsilon^{ax/A})$.



In the annexed diagram I have drawn this curve and distributed the observations with reference to it by so determining the constant $AUn_0e/Cln10$, that the first observations coincide ($c = .200$, $x = 1.7$). The agreement of the theoretical curve and the observations is so striking as to give great probability to the hypothesis that decay * is here relatively insignificant.

It is even possible to make an approach toward computing the constant, which since c in my observations is taken rela-

* See my paper in the *Physical Review*, X., p. 257, 1900, whence the data of this paper are taken.

* How much importance is to be attached to this decay (k') I shall show in experiments with spherical condensers in which the ions can not escape. These results, while giving no evidence of decay, show that dilution (since saturation must fall off at increasing distances from a central phosphorus emanator) is accompanied by additional ionization; *i. e.*, there is relatively too much current, *cæt. par.*, when the spherical condenser is larger.

tive to minutes instead of seconds, now becomes $K = 26A\,Un_0e/C$. For if the velocity of the ions produced by phosphorus is like that of other gaseous ions, U is of the order (say) of 1 cm./sec (Rutherford, Townsend, Chattock) and e of the order of 7×10^{-10} electrostatic units or 2.4×10^{-19} coulombs. The ratio of areas in my condenser was .35, the area $A = 132$ cm^2., the capacity C about 90 cm. or 10^{-10} farads. Finally the observed value of K as used in computing the above curve was $K = .634$. Thus the initial saturation $n_0 = .634 \times 10^{-10}/26 \times 132 \times 1 \times 2.4 \times 10^{-19} = 8 \times 10^4$ nearly. Hence if all the ions which reach and are absorbed by the condenser plates actually convey electric charge, less than $n_0 = 10$ ions per cubic centimeter occur in the saturated emanation contiguous to the surface of the phosphorus grid.

If now, instead of $U = 1$ cm./sec. for the field of a volt per centimeter, the absorption velocity $k = .3$ cm./sec. found in the absence of an electric field (*Am. Journ.*, March), were taken, the number n_0 would be about 3 times larger; in such a case a special mechanism of electrolysis, as I endeavored to sketch it elsewhere, is in question. What I wish chiefly to point out, however, is that the order of the velocities U and k, obtained from such widely different experiments, is about the same. Indeed if one supposes that but 1/3 of all the ions travel in a given cardinal direction, $3k$ will replace k in the above estimates, and the close proximity of $3k$ and U is even more striking.

C. BARUS.

BROWN UNIVERSITY, Providence, R. I.

SCIENTIFIC BOOKS.

Report of the U. S. Commissioner of Patents to Congress for the year ending December 31, 1900. Washington, Government Printing Office. 8vo. 1901. Pp. 19.

Among the many causes which have conspired to give the United States its present leading position in the industrial world, it may be doubted whether any single influence has been more potent than that liberal system of patent law which was established in the days of Washington and Hamilton, and which has been constantly under revision, usually and until lately with improvement, throughout the century. That defect which permits the inventor to secure a patent upon the simple presentation of a written claim, with a drawing or a diagram, and without any real work in successful reduction of the scheme to practise, and that which allows the inventor to secure indefinite retention of his legal claim—by the equally simple expedient of so wording his claims that the examiner will be sure to object, taking two years to frame another objectional claim, repeating this process, until the time is ripe for gathering in a profit—will be remedied whenever the committees of Congress choose. The few defects in the existing system are capable of instant remedy and its excellent features far outweigh its faults. That the Congress, the Commissioner, the public and especially the patent attorneys permit defects to remain is unfortunate; but it remains nevertheless the fact that we have the best system of patent-law yet produced and that it has done much and is still doing much to stimulate invention, to promote the efficiency of manufactures and to give prosperity to the country and to its average citizen. No more important duty lies with the legislative branch of the Government than that of sustaining and perfecting this code.

The Commissioner reports annually to the Congress. In the report before us he states the total receipts for the year 1900 at $1,350,828.53, the expenditures $1,260,019.62 and the profits for the year as the balance, $90,808.91.

The Patent Office has always made a profit on its business with the usually poor nventor, and this extortion of money from the greatest benefactor which this country knows in industrial fields has permitted the accumulation of an enormous sum, now reported by the Commissioner as $5,177,458.55 in the United States Treasury, standing at that figure on the books of the Treasurer to-day. In other words, the poor inventor has contributed not only thousands of millions to the wealth of the nation,

and placed the United States in the forefront of nations; but he has been compelled to spend practically all that he has received, in the average case, in the introduction of his invention —for the average inventor lives and dies poor, spending every dollar he can earn or borrow in promotion of his ideas and inventions—and he has, meantime, contributed over five millions of dollars to the treasury of the wealthiest nation on earth while giving that nation's inconceivable advantage and position.*

It would seem that the inventor may well claim that he is treated with unconscionable inequity and ingratitude; but the depth of that inequity and ingratitude is not yet sounded. He has deposited in the United States Treasury, out of a painfully-earned pittance, in the course of a century, in the small contributions made by thousands of patentees, $5,000,000; which sum is definitely pledged by the nation to the purposes of the Patent Office and of the inventor for whose benefit it is in part established. Meantime, the Patent Office has been for years painfully crowded, its work seriously impeded and its employees have suffered, as well as the inventor and the industries of the country, through lack of proper provision for its work and of suitable space for its collections, papers and models, and its library, all of which are in constant danger from fire. Other divisions of the Department of the Interior have been for years past squatting in its territory and occupying valuable and needed space, belonging to the Patent Office and in its own building, while five millions of dollars belonging to it and the inventor are hoarded in the United States Treasury with its hundreds of millions surplus, and its use withheld either for constructing a new and suitable fire proof building —the proper course—or for relieving the existing embarrassment in other ways. Truly 'Republics are ungrateful'!

During the year 1900, over forty thousand patents were applied for and nearly six thousands caveats, trade-marks and designs. Twenty-six thousand patents were issued and twenty-one thousand expired. New York heads the list with 3,788 patents and Pennsylvania and Illinois follow with 2,564 and 2,439; but Connecticut leads in inventiveness; securing one patent to every 1,203 inhabitants; although the District of Columbia is reported to have one to each 1,110. The latter is of course not precisely comparable with the States; the patents being often taken out by immigrants, coming to the capital for the purpose, or by residents uniting with the inventor in application for the patent. About one in 1,500 New Englanders takes out a patent each year. The average for the country is about one patent in the year for each four thousand inhabitants. The 'Yankee' is about twenty times as inventive as the South Carolinian. Women have about one patent in each 1,000. The number of patents issued has of late years been nearly stationary at about 22,000; growth having apparently practically ceased about fifteen years ago.

Inventors complain that the law and the administration, and especially the courts, have recently often been inclined to bear hardly upon the man who provides the people with their main instrument of prosperity. Certain States are well known among patentees as dangerous, through their adverse court-decisions, and the United States District Courts and even the Supreme Court of the United States are sometimes thought too indifferent to the rights of the inventor and of the people in this direction. It is, however, hardly possible for a court to invariably exhibit the knowledge or the judgment of the expert in the field of mechanics, and the famous decision of the latter court, when it was decided in the great Sickels-Corliss case that a latch is not a catch and that a dash-pot and another dash-pot are not equivalent, must be expected to be occasionally paralleled. Something should be done, however, to restore to the inventor that consideration which was formerly his and which has of late been in some degree lost to him, in part perhaps, through familiarity with his work and through the very extent and universality of his beneficence.

As to the standing wrong—refusal to prevent

* This reminds one of the action of a Legislature of the State of New York which compelled Ezra Cornell to pay $25,000 for the privilege of endowing the Land-Grant College of that State with $500,000 and 200 acres of land to be succeeded later by millions of dollars from Cornell, Sage, Sibley, White and others.

the use of his own funds for the construction of a suitable government building for his benefit, in which fire-proof construction shall insure the safety of invaluable records and where ample space and every convenience shall insure prompt attention to his business—the senior senator from Virginia has recently admirably stated the case:

"Other nations have surpassed us in literature and the fine arts, but in inventive and useful arts the United States is far transcendent. The Patent Office, established by Thomas Jefferson and protecting for a brief period the only constitutional monopoly, the right to the exclusive enjoyment of one's original ideas, is the crown of American intellectual supremacy over the material world, even as the Constitution of the United States is the crown of political architecture and the Union itself the crowning glory of our people.

"As Francis Bacon says, 'The sciences dwell sociably together,' and we should put on Capitol Hill, facing the Senate Hall, as a companion piece to the exquisite Library building now facing the Hall of Representatives, another building of like architecture. And the American capitol of letters should have by its side the American capitol of inventive art, both facing the Capitol of the people, where their sovereignty has its highest exemplification. In that hall should be displayed the evolutions of inventions, with every invention indicated by its model, inclusive of the last improvement. It would be the greatest college of applied science that the world has ever seen; a monument to and a stimulus to invention, and leading by gradations to those truths of science which hover over the threshold of the age, 'waiting to be caught.'"

R. H. THURSTON.

Photographic Optics. By OTTO LUMMER, Professor, Assistant in the Reichsanstalt, Berlin; translated by Professor S. P. THOMPSON, London, Macmillan & Co.

A very complete and concise treatment of the theory of the modern photographic objective, with a full exposition of von Seidel's theory of aberration. The subject as a whole is rather deep for the general reader, though portions of the book cannot but help interest any who desire to know more about the various modern objectives; though they may not be able to penetrate the mysteries of the five different kinds of spherical aberration, and two chromatic aberrations which are taken into account in the computation of the complicated optical systems in use at the present time, they will find much of interest. A perusal of the book will at least give the photographer a respect for, and appreciation of his instrument far greater than can be had by the inspection of a few negatives and a glance at the optician's bill. A photographer should at least know as much about his lenses as an engineer knows about his engine, and yet how few can tell why the stop is placed in front of the lens-system in some cases and between the lenses in others, and to how many is a Zeiss 'Planar' anything more than a lot of pieces of glass stuck together and mounted in a brass tube. To the optician the book will be invaluable, it being practically the only work on the subject extant. R. W.

Geometrical Optics. By R. A. HERMAN, Fellow of Trinity College, Cambridge. Published at Cambridge by the University Press.

This book covers about the same ground as Heath's well-known work, which it resembles in some respects. The author has adopted a geometrical method instead of the usual analytical method in his treatment of refraction by coaxial surfaces and aberration, and makes use of the reduced path rather than the characteristic function in discussing Maxwell's theorems.

R. W.

DR. GRAY'S FAMILIAR TALKS ON SCIENCE.

A SERIES of little books, entitled 'Nature's Miracles or Familiar Talks on Science' (Fords, Howard and Hurlbut), has been published by Dr. Elisha Gray, and the third volume on 'Electricity and Magnetism' appeared shortly before his death, which occurred in January of the present year. Dr. Gray was unquestionably one of the prominent inventors who contributed his share to the very remarkable progress of electrical science and its application during the past thirty years. The claim often made for him that he was the inventor of the telephone is not justified by the

decisions of the courts. His work in connection with the harmonic telegraph, a very interesting invention which belongs to him, led him to an understanding of the principles underlying the telephone, and the caveat which he filed in the patent office showed that he was very close to the realization of his ideas in this direction. Nevertheless, the fact that Mr. Bell had shown and described an apparatus capable of actually transmitting speech and one which survives to-day as the receiving instrument, gave him a more positive claim which, in connection with other technical and legal facts, resulted in a final decision in his favor. The telautograph, like the harmonic telegraph, has not yet become of great practical value, although both are ingenious and beautiful devices. It would seem that Dr. Gray had been most unfortunate with his inventions in spite of his natural genius. It was not due, however, to lack of mental clearness or grasp, but more likely resulted from insufficient business ability. The books which he has recently written reflect very faithfully the mind of the man. To him science was not abstruse or formal, but a familiar, matter-of-fact and attractive subject. In a clear and picturesque style, he treats the principles and applications of electricity as well as other branches of science. These books could be understood sufficiently to be interesting even by the least technical of readers. On the other hand those well acquainted with the subjects would find at least a new point of view. It is notoriously difficult to write a really satisfactory scientific book of an elementary character. This inherent difficulty is magnified by the fact that most persons who undertake it are not masters of their subject. No such criticism can be made of Dr. Gray, and the lucidity of his ideas and his language are adapted to the task. The writer was well acquainted with Dr. Gray personally and knew his great enthusiasm for science, which is another quality necessary in the writer of an elementary work, in order to inspire his readers who are beginners or those who have comparatively little taste for such matters. For these reasons the series of books that Dr. Gray has written are to be recommended as interesting and instructive to the general or even casual reader, but they are too conversational for use as text-books, except perhaps to supplement other more formal works.

F. B. Crocker.

Columbia University.

March 6, 1901.

Books Received.

Hygiene and Public Health. Louis Parkes and Henry Kenwood. Philadelphia, P. Blakiston's Son & Co.; London, H. K. Lewis. 1901. Pp. xix + 732.

The Agricultural Experiment Stations in the United States. A. C. True and V. A. Clark. Washington Government Printing Office. 1900. Pp. 636.

Experimental Psychology, a Manual of Laboratory Practice. Edward Bradford Titchener. New York and London, The Macmillan Company. 1901. Pp. xviii + 214.

The Human Nature Club. Edward Thorndike. New York, London and Bombay, Longmans, Green & Co. 1901. Pp. vii + 235.

Practical Organic Chemistry. Julius B. Cohen. New York and London, The Macmillan Company. 1899. Pp. xiii + 200.

Practical Gas-Fitting. Paul N. Hasluck. London, Paris, New York and Melbourne, Cassell & Company, Limited. 1900. Pp. 160.

A Manual of Elementary Science. R. A. Gregory and A. T. Simmons. New York and London, The Macmillan Company. 1901. Pp. viii + 429.

The Industrial Revolution. Charles Beard. New York, The Macmillan Company. 1901. Pp. x + 105. 40 cts.

Societies and Academies.

Biological Society of Washington.

The 336th regular meeting was held on Saturday evening, March 9th.

C. W. Stiles presented a note on a recent visit to Texas, whither he had been called to investigate a disease of cattle ascribed to the presence of a parasite in the lungs. He had discovered that the disease was really due to a parasite of the genus *Strongylus* which infested the fourth stomach of the animals infected.

Barton W. Evermann read a paper on 'The Feeding Habits of the Coot and other Water Birds,' based upon observations made at Lake Maxinkuckee, Indiana, by Dr. Evermann and Mr. H. Walton Clark. In 1899 the observations

covered the period from July 1st to October 18th, and in 1900 they began July 1st and have been continued up to date.

Many very interesting observations were made regarding the feeding and other habits of the coot and numerous species of ducks. The paper was devoted chiefly to the coot, the habits of which, at this lake, were found to differ widely from most of the published records of its life history.

It was found that the coot is quite as aquatic in its habits as are most ducks; it swims freely and easily in all parts of the lake. It dives regularly and gracefully when feeding, and in water as deep as twenty-five feet, though its usual feeding grounds were in water four to eighteen feet deep. The longest time any individual was observed to remain under water was sixteen seconds in water ten to twelve feet deep. In deeper water the time was doubtless longer, but could not be definitely determined.

The choice food in September and October was the modified stolons or winter buds of the wild celery (*Vallisneria spiralis*), but later other parts of this plant, and other plants (among them *Myriophyllum verticulatum*, *Potamogeton pectinatus* and other Potamogetons) were utilized. When feeding, which it does at all hours of the day and night, it is not taciturn, as stated by Nuttall, but very sociable and loquacious, constantly talking to its associates day and night; as an article of food the coot is superior to many species of ducks.

Mr. Clark is continuing his observations at Lake Maxinkuckee during the winter and spring, and doubtless other interesting facts will be discovered.

Under the title, 'More about the Cocoanut,' O. F. Cook continued the argument brought forward in a previous paper that the cocoanut palm is an American and not an Asiatic or Malayan species, and that its original habitat is not to be sought on the sea-coast, but in the mountains of Colombia, where it has been reported far inland. It is apparently unable to establish or maintain itself in competition with the usual floras of tropical coasts, and its general dissemination and present range are believed to be the result of human agency. The prehistoric distribution, the Malayo-Polynesian names, and the uses attaching to the cocoanut, the sweet potato and other economic plants of American origin, suggest the probability of a very early westward migration of a primitive culture-race.

A. H. Howell gave some 'Notes on the Distribution and Nomenclature of North American Skunks,' recognizing seventeen species and subspecies and showing specimens illustrating their color variations. Several important changes in nomenclature were referred to, the details of which will be given in a revision of the group about to be published by the Biological Survey of the Department of Agriculture.

F. A. LUCAS.

CHEMICAL SOCIETY OF WASHINGTON.

THE 124th regular meeting was held on February 14th. Dr. H. Carrington Bolton, the retiring president, addressed the Society on the subject 'Physics and Faith.' (SCIENCE, XIII., 320.)

The following papers were then presented: 'The Solubility of Gypsum in Aqueous Solution of Sodium Chlorid,' by F. K. Cameron. This paper was a description of the continuation of investigations along this line previously reported by the author. It was found that the solubility curve presented a maximum point even when calculated on the basis of a given mass of solvent instead of a given volume of solution. A discussion together with the results of experiments was given on the nature of the hydrate of calcium sulfate in the solid phase in contact with certain solutions. A theoretical discussion of the results was presented, and some practical applications pointed out.

'Equilibrium between Carbonates and Bicarbonates in Aqueous Solution,' by F. K. Cameron and L. J. Briggs. The curves showing the distribution of the base between the two salts for solutions in equilibrium with ordinary air were shown. For solutions of the salts of sodium, potassium, or magnesium, as infinite dilution is approached, the bases are all combined as hydrogen carbonates. As the total concentration increases, the percentage of base combined as normal carbonate increases rapidly to a certain point, then asymptotically

and as the solutions approach high concentration, there is again a falling off showing the existence of maximum points on the curves. Solutions of calcium salt contain so little normal carbonate when in equilibrium with air, that practically they may be considered as containing only the hydrogen carbonate. With rise of temperature in all cases, there is an increase in the proportion of normal carbonate in the solution, and at 100° C. all the base is combined as normal carbonate for practically all concentrations. A theoretical discussion accompanied the paper, and practical applications of the results were pointed out.

L. S. Munson,
Secretary.

PHILOSOPHICAL SOCIETY OF WASHINGTON.

The 531st meeting was held March 2, 1901. Under the head of informal communications Mr. Farquhar stated that eye observations on the Nova and Perseus showed considerable fluctuations in brilliancy from night to night. Mr. Bauer stated that the Toronto magnetic observations at the time of the Solar eclipse showed a slight disturbance coincident with the passage of the sun's shadow. Analysis shows that this is due to causes outside the earth's crust, and probably due to changes in the upper atmosphere caused by the passage of the shadow.

The first regular paper was a report by Father Hagen on 'Progress in Astronomical Photometry.' It grouped the facts into four classes:

1. *Photometric Catalogues* with regard to brightness and color of stars. Special mention was made of the Harvard Photometry and of Osthoff's catalogue of star colors.

2. *Original Observations of Variable Stars* were mentioned, in particular those published lately by Peck, Knott and Pickering.

3. The *Physical Explanation* of the light variations is advanced by the discovery of coincidence between the light curves and velocity curves in the three variable stars: δ Cephei, η Aquilae and ζ Geminorum.

4. Various *Charts for Variable Stars*, distributed or published for the convenience of observers, were mentioned, with special reference to Pogson's charts. This part of the report was illustrated by lantern slides.

The next paper was a report by Mr. Radelfinger, on 'Progress in Pure Mathematics in 1900.' This dealt first with important books, referring to the great Mathematical Encyclopedia now in course of publication, and to Forsyth's 'Differential Equations' in two volumes. A brief historical account of the treatment of the ordinary differential equation from the time of Briot and Bouquet introduced an outline of Painlevé's very recent and successful attack on the equation of the second order: he had discovered three new uniform functions, and completely solved the problem of determining all equations of the second order whose integrals are uniform functions. Painlevé's method promises important results from its application to equations of higher orders.

Professor See's report on the 'Progress of Astronomy in 1900' dealt very briefly with the publication of the results of the observations on the Transit of Venus; the observations on Eros, in which about 50 observatories are engaged; the discovery of several hundred double stars, and the publication of double-star catalogues; The observations at the Naval Observatory of planetary diameters with a color-screen; and Rees's new determination of the constant of observation, which he finds to be 20″.464.

Charles K. Wead,
Secretary.

GEOLOGICAL SOCIETY OF WASHINGTON.

At the 111th meeting, held on February 27, 1901, at the Cosmos Club, the following papers were presented:

Memorial of Thomas Benton Brooks: Mr. Bailey Willis. (Published in Science March 22.)

Morphogeny of Southern Alaska: Mr. G. K. Gilbert.

Mountain Structure in the Trans-Pecos Province of Texas: Mr. Robert T. Hill.

The last two papers were illustrated by lantern slides.

F. L. Ransome,
David White,
Secretaries.

SECTION OF GEOLOGY AND MINERALOGY OF THE NEW YORK ACADEMY OF SCIENCES.

AT the meeting of the Section on February 18, 1901, the following program was presented:

'The Granite of Barre, Vermont,' by George I. Finlay. The speaker described the occurrence of the granite as a single intrusion through the country rock, which is a biotite schist, in the southeastern portion of Barre township. Many inclusions of the schist are found in the granite, and this rock has almost surrounded other masses of the schist which remain in place, with their original strike and dip unchanged. The speaker employed a series of original lantern views to illustrate the character of the jointing, the 'onion structure,' and the zones of shearing, together with certain large systems of joints, standing at right angles to each other, resulting from pressure. Microscopic examination shows that the granite consists of microline and orthoclase, plagioclase, in very small amounts, quartz, biotite and muscovite, with occasional crystals of apatite and magnetite and rarely pyrite. Variations in the shade of the marketable granite, from very light to very dark gray, are due to the relative amounts of biotite which it contains. The rock is of medium grain and its constituent minerals are but slightly weathered. Pegmatitic offshoots, traceable directly to the granite mass were recorded by Mr. Finlay, and their dynamic effects on the enclosing schists were illustrated. The contact metamorphism of the schist is inconsiderable. It is chiefly shown in the greater abundance of biotite and quartz in the immediate vicinity of the granite. Two dikes of augite-camptonite were found; one in the granite, the other in the country-rock. They are notable for the manner in which they have weathered. At times sixteen successive shells may be counted which are ready to break away from the main mass of the dike. Mention was also made, in discussing the glacial geology of the region, of sand plains and of two well developed eskers.

The paper was discussed by Professors Kemp and Dodge and Drs. Julien and White.

'Note on a Sand Fulgurite from Poland,' by A. A. Julien. Dr. Julien exhibited a specimen of Fulgurite formed from sand, in Poland, with a series of micro-photographs which he had made from the same. Some new features in fulgurites were pointed out in this specimen: pustules of glass on the inner lumen, glass-fibers on the exterior, and adhering sand-grains, two-thirds of which consist of orthoclase. In the thin cross-section, examination of the minute gas-cavities showed the absence of condensed water-vapor, and this indicated a dilatation of both lumen and cavities by air, more than by steam. The radial arrangement of layer cavities, the hornlike projections on the exterior of the tube, and the pustules along the lumen were all shown to be connected with relief of intense pressure outwardly during the electric discharge, or inwardly during the reaction after its passage. This fulgurite is of further interest in presenting the first instance yet observed of devitrification, the glass being generally filled with delicate crystallites, apparently of feldspar. All the bubbles, however, are enclosed in pellicles of homogeneous glass, and some of the larger within a coating of suddenly chilled glass, which is free from crystallites. The relation of these facts was discussed in reference to Lagorio's view as to the difficult saturation of a magma by the constituents of feldspar.

Other occurrences of fulgurites were discussed by Drs. Kemp, Levison and White.

THEODORE G. WHITE,
Secretary.

THE MINNESOTA ACADEMY OF NATURAL SCIENCES.

THE February meeting of the Academy was addressed by Professor N. H. Winchell and Mr. Warren Upham on the following topics, respectively: 'The Retreat of the Ice Margin Across Minnesota' and 'Giants' Kettles in the Interstate Park, Taylor's Falls.'

Professor Winchell called attention to the general topography by means of a map of the State divided into three areas, viz.: Those areas above 1,400 feet, those between 1,400 and 1,300 feet, and those below 1,300 feet, remarking that, as the ice must have slowly encroached, in the form of glaciers, in the low-

lands, so it must have left the State last in the lowlands. That necessitated the two great ice-lobes, one from the north and northwest and one from the northeast. The former occupied the basin of the Red river of the North and the Minnesota valley, and the latter the valley of Lake Superior with its western tributaries. These at length united in one general ice sheet, but when they retired they assumed again their lobate forms outlined by moraines, and finally allowed an uncovered interlobate area of the high lands about the region of the Upper Mississippi. By the growth of this uncovered area the ice lobes shrank to smaller dimensions and disappeared entirely, the latest to finally leave the State being the northeastern lobe.

The belt along which these ice lobes collided in the central part of the State can be traced by the overlapping and confusion in the characters of the drift, the northwestern drift being normally gray and the northeastern red. This belt he marked out in general as continuing from Rice county to St. Paul, thence northwestwardly to the region of Itasca lake where it turns eastward, passes along the range known as Giant's range, and leaves the State not far from the extremity of Pigeon point. Wherever these ice-lobes uncovered land that slopes northerly, or toward the ice itself, the discharged waters formed lakes whose outlets, beaches and areas are sometimes well known, the chief of which is Lake Agassiz, described by Mr. Warren Upham. Twenty-five other such lakes were defined by Professor Winchell within Minnesota, varying in elevation from 890 feet to 1,700 feet above sea level.

Mr. Upham, in his lecture on 'The Giants' Kettles in the Interstate Park,' stated in substance that within an area of two or three acres in the northern part of the Interstate Park are found about seventy rock potholes, or giants' kettles, as they may be called in agreement with their common designation in the languages of Germany, Sweden and Norway. This area of their abundant occurrence is unsurpassed in respect to their numbers, depth and difficulty of explanation, by any other locality in the world, although many places, as in Maine, nearly all the other New England States, the vicinity of Christiania, Norway, and the Glacier Garden in Lucerne, have very remarkable giants' kettles.

At Taylor's Falls they range in diameter from a foot or less to 25 feet, and in depth from one foot or a few feet to 63 feet and 84 feet, these being the depths to which two potholes 25 feet apart have been excavated and sounded, but without yet reaching to their bottoms. In many cases the ratio of diameter to depth is as 1 to 5 or 1 to 7 with nearly cylindric, but occasionally somewhat spiral or rifle-like, form. The rock is the very hard Keweenawan diabase, scarcely exceeded in hardness by any known rock. From many features of these giants' kettles, as notably their abrupt rims and the generally unworn adjoining rock surface, Mr. Upham attributed their erosion to torrent-falling through moulins, vertical shafts of the ice sheet which covered this region in the Glacial period. Some of these kettles were filled and covered by drift, but the greater number are empty, excepting scanty gravel at the bottom, with a few water-rounded boulders. The adequacy of moulin torrents to erode the smaller as well as the larger kettles is shown by small potholes of such origin, in some instances only about a foot or two in diameter and depth, on the high ridges and tops of hills and mountains in Maine, New Hampshire and Vermont.

The above is but a brief summary of these two very instructive lectures which were delivered to a large audience in the Academy Assembly Hall.

F. G. Warvelle.

SHORTER ARTICLES.

CHIASMODON IN THE INDIAN OCEAN.

The Indian government survey steamer *Investigator*, Captain T. H. Henning, R. N., commanding, which has recently been engaged in beam-trawling off Cuddalore and Point Calimere on the southeast coast of India, has obtained a small specimen of the rare deep-sea fish, *Chiasmodon niger* Johnson, from a depth of 1,100 fathoms.

This species has hitherto been known only from four localities in the Atlantic. It was first reported from the Madeira Islands in 1850,

but not fully described until 1863, when Johnson obtained another specimen in that locality. Two other specimens have since been found at the surface (near the island of Dominica and on the Lehave Bank). The *Challenger* took another with the trawl at a depth of 1,500 fathoms in the mid-Atlantic.

Chiasmodon is remarkable for its large mouth and distensible stomach, enabling it to swallow fishes larger than itself. For most of the foregoing specimens, naturalists are indebted to the inability of the fish to digest what it swallows, resulting in its death and appearance at the surface.

H. M. SMITH.

U. S. FISH COMMISSION, WASHINGTON, D. C.

THE SAN JOSÉ SCALE PROBLEM AS COMPARED WITH THE ORANGE SCALE PROBLEM.

I WAS much interested in the communication of Professor Kellogg in the issue of SCIENCE for March 8, 1901. Of course the practical value of Mr. Kuwana's investigations is in the increased probability of our being able to import from Japan the natural enemies of the San José scale, and thus control the pest here, as was done in case of the *Icerya*. It is, therefore, of interest to see where we now stand in the matter of information, on which to base a second experiment in importing into this country parasitic enemies of scale insects. I copy the following lines from Professor Kellogg's communication:

* * * "It the [San José scale] is attacked by several enemies, Mr. Kuwana personally finding one chalcid, three lady-bird beetles and one moth, the larva of which feeds on the scale. Of these enemies the chalcid fly and one of the lady-bird beetles are everywhere common, and are effective checks to the increase of the scale. It is probable that the comparatively little injury produced by the scale in Japan, widespread as it is, is due to the presence of these natural enemies." * * *

By the side of this information may be placed the following, extracted from the Adelaide, South Australia 'Garden and Field' of November, 1887, by the late Mr. Frazer S. Crawford, who, from first to last, gave such efficient aid in bringing about the introduction of the Vedalia lady beetle that suppressed the Orange scale in California.

* * * "We have a few species of Coccinellidæ about Adelaide, but they are not very plentiful, and although one or more species attacks the *Icerya*, yet they are not very effective in keeping them under, as the following experiment proves. Three months ago I put in a glass bottle a small branch of a gooseberry tree, on which some forty or fifty adult Iceryas were clustered. On examining them subsequently I discovered two lady-bird larvæ, which have lived to the present time feasting on the *Icerya*, evidently contented with their quarters; but at the present time there are likewise a great number of young larvæ, lately hatched, running about, thus showing that the work of destruction has been very slow, and that even under such favorable circumstances the coccinellæ larvæ cannot cope with the productive power of the *Icerya*. Strange to say, a similar twig, covered with about the same number of adult females, was about the same date placed in a lemon tree, and a fortnight back every vestige of *Icerya* had disappeared. This clearance was gradual, but what has caused it I am at a loss to say." * * *

It must be remembered that this was written one year prior to Mr. Keoheles starting for Australia on his first trip. It will thus be seen that Mr. Kuwana has thrown a flood of light upon this problem which I can only look upon as very similar to the one in which *Icerya* was involved, and afterwards so effectually solved. As I read of the conditions of the San José scale in Japan, as relating to numbers and effect, it seemed to coincide exactly with the mental picture that I could not banish from me when I went over some infested nursery stock two or three years ago, just received direct from Japan. While I had practically nothing to do with the introduction of the *Vedalia*, I did examine many orange groves about Adelaide, South Australia, for the *Icerya* and found a similar condition—only here and there a solitary individual, at most two or three together.

We can make a *defensive* fight against the San José scale with whale oil soap, petroleum, the axe and fire, in fact we must do so, in order to save our orchards from ruin; but we shall never be able by these measures to do more than check the pest. If we ever expect to do more than this we must make an *offensive* fight and with natural enemies brought from the country where they are found doing their work and holding this pest perpetually below the danger line in point of numbers.

F. M. WEBSTER.

WOOSTER, OHIO, March 12, 1901.

NOTE.—Since the above was written, Dr. Howard informs me that Mr. C. L. Marlatt sailed for Japan on March 5th, his mission being to collect and forward such natural enemies of the San José scale as he may find in that country.

F. M. W.

CURRENT NOTES ON METEOROLOGY.

CLIMATE OF ARGENTINA.

ONE of the most important publications on climatology issued in recent years is buried in the second census of the Argentine Republic (Buenos Aires, 1898. Tomo I. Cuarta Parte. *El Clima de la República Argentina*, por Gualterio G. Davis. Pp. 259–381). This monograph is printed with a mass of other material in the volumes of the Argentine Census. No reprints of it have been struck off and it has so far practically escaped notice. Mr. Walter G. Davis, who is well known as the Director of the Argentine Meteorological Office, has in this report given an admirable presentation of the chief climatic features of Argentina, and has included a series of isothermal, isobaric and isohyetal charts which are of unusual interest. The interest of Argentina from a climatological standpoint is chiefly due to the great extent of that country from north to south. On the north it extends just beyond the Tropic of Capricorn; on the south it reaches latitude 55°. The differences in the temperature and rainfall conditions over this extended territory are naturally very striking, and profoundly affect the natural products of the Republic and the occupations of its inhabitants. All the important climatologic elements are tabulated and discussed, and many excellent graphic representations are given, showing the correlations between the various elements at certain selected stations. But the most important matter in the report is the series of charts showing the distribution of temperature, pressure and rainfall. The data used are the latest, the most complete and the best obtainable. There are isothermal charts for spring, summer, autumn, winter and for the year (reduced to sea-level and without reduction to sea-level); isobaric and wind charts for the seasons and for the year, and a mean annual rainfall chart. These charts show, for the first time, the distribution of these various elements over the southern portion of South America, in detail, and on the basis of reliable data. The extraordinary decrease of pressure to the southward is perhaps the most striking feature shown on these charts. In each season, as well as for the year, the isobars in the southern part of the Argentine run closely parallel, almost due east and west. Mr. Davis's report is altogether an extremely valuable piece of work, which should certainly be reprinted and made generally available for the use of students of climatology.

MONTHLY WEATHER REVIEW.

THE November number of the *Monthly Weather Review* is particularly strong in papers dealing with climatological subjects. W. H. Alexander, Observer of the Weather Bureau on the island of St. Kitts, contributes an article on the 'Rainfall of the Island of St. Kitts, W. I,' in which the effects of topography upon the amount of precipitation are clearly brought out. 'The Climate of Spokane, Wash.,' is discussed by Charles Stewart on the basis of eight years' records. A. G. McAdie contributes another paper on 'Fog Studies on Mount Tamalpais' (Cal.), which is illustrated by four excellent half-tones, the original photographs having been taken from the U. S. Weather Bureau Observatory on Mt. Tamalpais. The Section Directors of Colorado, Idaho, Montana, New Mexico, Utah and Wyoming discuss the question of 'The Water Supply for the Season of 1900 as Depending on Snowfall.'

NOTES.

THE *Monthly Review of the Iowa Weather and Crop Service* for December contains a paper on 'Climatology of Iowa,' by J. R. Sage, read before the State Horticultural Society, Dec. 13, 1900, and a discussion of the 'Losses by Hailstorms in 1900.' A table prepared by the officials of the Farmers' Mutual Hail Insurance Association shows that an aggregate of 2,202 farms, in 64 counties, suffered damage to the amount of over $140,000.

THE *Meteorologische Zeitschrift* for December contains an excellent brief summary, by Exner, of recent contributions to the study of atmos-

pheric electricity. A bibliography accompanies the article (Ueber neuere Untersuchungen auf dem Gebiete der atmosphärischen Elektricität).

R. DEC. WARD.

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*YELLOW FEVER.**

1. Sufficient search reveals the presence of a fine small bacillus in the organs of all fatal cases of yellow fever. We have found it in each of the fourteen cadavers examined for the purpose. In diameter the bacillus somewhat recalls that of the influenza bacillus; seen in the tissues; it is about 4 μ in length.

2. This bacillus has been found in kidney, in spleen, in mesenteric portal and axillary † lymphatic glands, etc., taken from yellow fever cadavers directly after death. In the contents of the lower intestine apparently the same bacillus is found often in extraordinary preponderance over other micro-organisms. Preparations of the pieces of 'mucus,' which are usually, if not always, present in yellow fever stools, at times may almost present the appearance of 'pure culture.'

3. Preparations of the organs usually fail to show the presence of any other bacteria, whose absence is confirmed by the usual sterility of cultivation experiments.

4. It is probable that this same bacillus has been met with, but not recognized by three other observers. Dr. Sternberg ‡ has mentioned it; and he has also recorded the finding of similar organisms in material derived from Drs. Domingos Freire and Carmona y Valle; but he did not recognize its presence frequently, probably on account of the employment of insufficiently stringent staining technique.

5. It is probable that recognition has not been previously accorded to this bacillus by reason of the difficulty with which it takes up stains (especially methylene-blue), and by reason of the difficulty of establishing growths on artificial media.

6. The most successful staining reagent is carbolic fuchsin solution (Ziehl), diluted with 5-per-cent. phenol solution (to prevent accidental contamination during the long staining period) immersion for several hours, followed by differentiation in weak acetic acid. Two hours staining period may fail to reveal bacilli, which appear after 12 to 18 hours. The bacilli in the stools are often of greater length than those in the tissues, and they may stain rather more easily; naturally the same is true of cultures.

7. Since the bacilli are small and comparatively few in numbers they are difficult to find. To facilitate matters at our last two necropsies (14th and 15th) a method of sedimentation has been adopted. A considerable quantity of organ juice is emulsified with antiseptic solutions, minute precautions against contamination and for control being taken; the emulsion is shaken from time to time and allowed to settle. The method is successful and may form a ready means of preserving bacteria-containing material for future study. The best fluid for the purpose has yet to be worked out; hitherto normal saline with about one-fifth per cent. sublimate has been employed.

8. Pure growths of these bacilli are not obtained in ordinary aërobic and anaërobic culture tubes.

9. Some pure cultures have been obtained by placing whole mesenteric glands (cut out by means of the thermo-cautery) into broth under strict hydrogen atmosphere. Investigations into the necessary constitution of culture media for successful cultivation are in progress.

10. Much search was made for parasites of the nature of protozoa. We conclude that yellow fever is not due to this class of parasite. Our examinations were made on very fresh organ juices, blood, etc., taken at various stages of the disease, with and without centrifugalisation,* and on specimens fixed and stained in appropriate ways. We may add that we have sometimes examined the organs in a fresh state under the microscope within half an hour after death.

11. The endeavor to prove a man-to-man

* Abstract of interim report by Herbert E. Durham and (the late) Walter Myers to the Liverpool School of Tropical Medicine.

† We find these constantly enlarged and much injected, though whether this is specific we are not able to say.

‡ *Report on Etiology and Prevention of Yellow Fever*, 1890.

* We have found this sometimes useful in examining the blood of ague patients.

transference of yellow fever by means of a particular kind of gnat by the recent American Commission is hardly intelligible for bacillary disease. Moreover, it does not seem to be borne out by their experiments, nor does it appear to satisfy certain endemiological conditions. It is proposed to deal more fully with the endemiology and epidemiology of the disease on a later occasion.

12. We think that the evidence in favor of the etiological importance of the fine small bacillus is stronger than any that has yet been adduced for any other pretended 'yellow fever germ.' At the same time there is much further work to be done ere its final establishment can be claimed. The acquisition of a new intestinal bacterium would explain the immunity of the 'acclimatised.'*

THE NEW STAR IN PERSEUS. †

THE first news of Anderson's discovery of a new star in *Perseus* was received at this Observatory on February 24th. An examination of the region near the star, made that evening with the 40-inch telescope, failed to show any evidence of nebulosity, but the bright moonlight would have rendered a faint nebula invisible. At that time the magnitude of the star appeared to be about 0.5. Its color was yellow, with a decided reddish cast, very similar to that of *α Orionis*. Very little time was spent in examining the spectrum visually, as it was felt that photographs would be more valuable than drawings based on micrometer measures. We had fortunately just received a fresh supply of Erythro plates through the kindness of the International Color Photo Company of Chicago, and it was therefore possible to photograph the entire spectrum from *Hα* to *H'*. Beyond this point in the ultra-violet the absorption of the 40-inch objective greatly enfeebles the spectrum, which is still further weakened by the lack of perfect achromatism in this region.

Photographs of the spectrum were obtained by Mr. Ellerman on February 24, 25, 26, 27 and 28, March 4, 6 and 11. The comparison spectra which appear on these plates are those of titanium, hydrogen and sodium.

On February 24th and 25th Mr. Ritchey photographed the region of the *Nova* with the 40-inch telescope and color screen. In order to obtain a sufficient number of comparison stars the plates were given an exposure of one hour. The light of the *Nova* was intercepted by a small movable occulting disk, with which four (for the second plate, five) very brief exposures were given at intervals of about fifteen minutes. The total exposure for the *Nova* was probably about half a second. In the resulting photographs, the images of the *Nova* and the neighboring stars (of which more than forty appear in a region 12′ square) are small and appear to be well adapted for measurement. Through the kindness of Director Rees, these plates will be measured at the Columbia College Observatory. The position of the *Nova* was measured micrometrically by Professor Burnham on March 3d.

The wedge photometer used with the 40-inch telescope in the determination of standards of faint stellar magnitude has been employed by Mr. Parkhurst in measuring the brightness of the *Nova*. Hitherto objectives of one and two inches aperture have sufficed, but as the *Nova* decreases in brilliancy it will be followed with the 12-inch and 40-inch telescopes. A preliminary reduction gives the following magnitudes:

Date.	Mag.
1901, Feb. 25	1.0
" " 26	1.1
" " 27	2.0
" " 28	1.9
" Mar. 3	2.7
" " 4	2.8
" " 5	2.7
" " 6	3.1

A photograph of the spectrum (G 440) taken with the one prism spectrograph on February 28th has been measured by the writer. The resulting wave-lengths of the lines and bands, computed by the aid of Cornu-Hartmann formulæ, furnished data for attaching a scale to an enlargement of the photograph reproduced in the Bulletin.

* The completion of the interim report, of which this is an abstract, was interrupted by the onset of attacks of yellow fever in both of us. The loss of my much-lamented colleague renders it advisable to submit the shortened report only for the time being.—H. E. D.

† From Bulletin No. 16 from the Yerkes Observatory of the University of Chicago.

Inspection of the photograph will show that the spectrum is very similar to the earlier spectrum of *Nova Aurigæ*. The hydrogen lines, notably C and F, are bright and very broad. The dark lines superposed upon them are probably reversals caused by the absorption of an outer layer of cooler gas at lower pressure.

On the more refrangible side the hydrogen lines are accompanied by dark lines, just as was the case with *Nova Aurigæ*. As Wilsing has shown, this is doubtless due to the great pressure under which the radiation occurs. The bright sodium line has broadened into a band, on which appear the two dark D lines. These appear on the photographs, and are clearly visible in visual observations with a three-prism spectroscope. As the titanium poles were moistened with a weak solution of sodium chloride, the comparison spectrum contains the bright sodium lines. Thus the motion of the star in the line of sight can be measured. Some preliminary determinations indicate that the *Nova* is moving away from the earth at a low velocity.

The helium line D_3 seems to be present as a dark line, lying close to the bright sodium band on the more refrangible side. The bright calcium lines H and K are notable for their great breadth and for the narrow lines of reversal which traverse them. The chief nebular line seems to be present (λ 5002 – 5041), and a fainter line or band (λ 4911 – 4988) covers the region of the second nebular line. The *b* group of magnesium is doubtless represented by the very bright band λ 5154 – 5204. The green coronal line (λ 5303) would fall near the more refrangible edge of a bright band in the spectrum of the *Nova*.

Further results, based upon measurements of photographs taken with the three-prism spectrograph, will be given in a subsequent paper.*

MARCH 12, 1901. GEORGE E. HALE.

SCIENTIFIC NOTES AND NEWS.

PROFESSOR S. W. STRATTON has, in view of his appointment as director of the Bureau of Standards, resigned his professorship in the University of Chicago. He will go abroad soon to study similar institutions in foreign countries.

PROFESSOR GEORGE FREDERICK WRIGHT, of Oberlin College, arrived in New York on March 22d, after his geological expedition round the world.

DR. LEON VAILLANT, professor of zoology at the Paris Museum of Natural History, has been elected a member of the Zoological Society of London in the room of the late Alphonse Milne-Edwards.

AT the banquet offered to M. Marey, the eminent French physiologist, by the Paris Club Scientia, to which we have already called attention, it was decided to present him with a medal, and a committee for this purpose has been appointed. Subscriptions may be sent to M. Masson, treasurer, 120 Boulevard Saint-Germain, Paris.

THE University of Glasgow will confer, on April 23d, its LL.D. on Dr. A. W. Rücker, secretary of the Royal Society.

DR. G. A. HANSEN, the discoverer of the lepra bacillus, will celebrate his 60th birthday on July 29th, and the occasion will be celebrated by the erection of a marble bust in the Lungegaard Hospital, Bergen, where he discovered the bacillus.

THE Society of Italian Agriculturists has awarded a special honor to Professor Grassi for his services to agriculture by his investigations on malaria.

DR. G. TORELLI, professor of mathematics at Palermo, has been awarded the mathematical prize of the Naples Academy of Sciences.

SECRETARY LONG has called a meeting of the Board of Visitors to the Naval Observatory in Washington on April 9th. The board, it will be remembered, consists of Mr. St. Clair McKelway, of the Brooklyn *Eagle*, President William R. Harper, of the University of Chicago, Professor Edward C. Pickering, of the Harvard College Observatory, Professor Asaph

* Note added March 18th. A comparison of photographs taken on March 4th and March 15th, shows that the dark lines on the more refrangible edge of the bright hydrogen lines continue to increase in sharpness. At first single and rather diffuse, they have become sharply defined double lines. The *b* line of magnesium is apparently decreasing in intensity, and the calcium line K is much fainter than before.

Hall, Jr., of the University of Michigan, Professor Charles A. Young, of Princeton University, and Professor Ormond Stone, of the University of Virginia.

Captain Bernier was at Ottawa last week with a view to obtaining a grant from the Government for his polar expedition. He has also opened subscriptions in the principal Canadian cities. He estimates the cost of the expedition at $130,000.

The amount of new blood on the recently elected Council of the Geological Society of London is not great, being confined to Professor Theodore T. Groom and the Right Reverend J. Mitchinson, D.D. We see that Dr. Mitchinson was elected a Fellow only last year, but he was bishop of Barbados and is now master of Pembroke College, Oxford.

Dr. J. G. Adami, professor of pathology at McGill University, will attend the International Congress of Tuberculosis, to be held at London in July. He has been appointed vice-president of the section of pathology and bacteriology.

Professors Andrew F. West and J. Mark Baldwin, of Princeton University, have been appointed delegates to the Ninth Jubilee of the University of Glasgow.

Dr. Edwin A. Barber has been appointed secretary of the Pennsylvania Museum and School of Industrial Art and curator of the museum.

Dr. Asaph Hall has resigned from the Board of Managers of the Observatory of Yale University.

It is reported that the Secretary of the Navy has decided not to order the trial by court-martial of Professor Stinson J. Brown against whom charges were filed by Capt. Charles H. Davis, Superintendent of the Naval Observatory, but has detached Professor Brown from duty at the Observatory and placed him on waiting orders. He will be detailed for duty elsewhere as soon as an assignment can be found. It is also reported that Captain Davis will probably be assigned to the command of a ship in the course of the summer.

Mr. Fred J. Allen, of Auburn, N. Y., has been nominated by President McKinley as Commissioner of Patents in the place of Mr. C. H. Duell, who has resigned in order to resume private practice.

King Edward VII. has signified to the President and Council of the Marine Biological Association his pleasure in becoming the patron of the Association.

M. Anton Carlés is making progress with the model for the monument of Pasteur which is to be erected in his native town. In addition to the statue of Pasteur, which is said to be very effective, there is a model personifying science who holds a wreath of laurel towards Pasteur, and another figure of a woman holding two young children who are supposed to have been saved from death by Pasteur's discoveries.

Dr. George Pratt Starkweather, assistant professor of applied mechanics in the Sheffield Scientific School of Yale University, died at New Haven on March 21st. Dr. Starkweather graduated from the Sheffield Scientific School in 1891 and was last year promoted from an instructorship to an assistant professorship. He was only twenty-eight years of age.

Dr. George T. Fairchild, from 1879 to 1897 president of the Kansas State Agricultural College, died on March 16th, in his sixty-second year. He was at the time of his death professor of English Literature at Berea College.

Dr. John W. Griffith, for several years senior physician to the Finsbury Dispensary and medical officer of health to Clerkenwell, died recently at Camberwell in his 82d year. He was best known to naturalists as part author of Griffith & Henfrey's 'Micrographic Dictionary.'

The death is also announced of Mr. W. J. Williams, for many years clerical assistant to the secretary of the Zoological Society of London.

Alexander Macfarlane, M.A., D.Sc., LL.D., will deliver a course of six lectures entitled 'British Mathematicians of the Nineteenth Century,' at Lehigh University, beginning April 12, 1901. The life and work of the following will be presented in the order named: George Peacock (1791–1858); Augustus DeMorgan

(1806–1871); Sir William Rowan Hamilton (1805–1865); George Boole (1815–1864); Arthur Cayley (1821–1895); William Kingdon Clifford (1845–1879). Those interested are invited to attend. Tickets of admission can be secured by addressing Professor C. L. Thornburg at the University.

THE Newberry Research Fund from the income of funds raised by the Scientific Alliance, New York, has been increased by an addition of $50 by a gift of a friend of the Alliance. The award this year will amount to $100 by action of the Council of the Academy and will be made in geology or paleontology. Application should be sent immediately to Professor Henry F. Osborn, Columbia University, New York City.

THE following gentlemen have undertaken to be responsible for the indexing of the literature of Great Britain and Ireland for the International Catalogue of Scientific Literature in the subjects named: *Anatomy*—Professor G. D. Thane, University College, London; *General Biology*—Professor E. A. Minchin, University College, London; *Physiology* (including *Pharmacology*)—Dr. W. A. Osborne, Physiological Laboratory, University College, London, or to Professor W. D. Halliburton, King's College, London; *Experimental Pathology*—Dr. T. G. Brodie, Examination Hall, Victoria Embankment, London, W. C.; *Bacteriology*—Mr. S. G. Shattock, St. Thomas's Hospital Medical School, London, S. E.; *Experimental Psychology*—Dr. W. H. R. Rivers, St. John's College, Cambridge.

THE International Association of Academies will hold a meeting in Paris on April 16th.

THE fifth Triennial International Congress of Physiologists will be held at Turin from September 17th to 23rd in Professor Mosso's laboratory. There will be an exhibition of apparatus from September 14th to 23rd. Americans proposing to attend the Congress can address Professor F. S. Lee, Columbia University, New York City.

THE triennial convention of weather bureau officials will be held at Milwaukee, Wis., on August 27th to 29th.

A CIVIL SERVICE examination will be held on April 23d and 24th for the positions of geologist and assistant geologist in the Geological Survey for occasional service at a salary from $3 to $5 per diem.

ONE of the amendments to the Sundry Civil Appropriation Bill, passed by the fifty-sixth Congress, appropriated $35,000 for the erection of a laboratory for the investigation of infectious and contagious diseases and matters pertaining to the public health, under the direction of the surgeon-general. Five acres of land, on which is situated the Naval Museum of Hygiene, have been set apart for the building.

THE California Legislature has appropriated $100,000 for the State Board of Health to be used for the suppression of the plague. The Legislature has also passed a most extraordinary bill making it a felony to publish, by writing or printing, that Asiatic cholera or bubonic plague exists within the State unless the fact has been determined by the State Board of Health and entered upon its minutes. The San Francisco papers have apparently been only too ready to suppress information in regard to the plague in that City, and the passage of a bill of this character at the present time seems almost incredible. It has for a long time been known in medical circles that there have been cases of plague in the Chinese quarters in San Francisco, but the State authorities have denied their existence and have attempted to suppress any information in regard to the epidemic. It appears that Secretary Gage appointed some time since, in spite of the protest of the Governor of California, a commission to investigate the matter. This commission, consisting of Professor F. G. Novy, of the University of Michigan, Professor Simon Flexner, of the University of Pennsylvania and Professor L. F. Barker, of the University of Chicago, has made a thorough investigation and has presented a report which for the present has not been made public. In the meanwhile the Governor of California has sent a commission to Washington to protest against Federal interference, and has recommended a local investigation. It appears that the epidemic in San Francisco is but slight, but it will naturally be exaggerated by attempts to deny its existence for commercial reasons.

GOVERNOR VORHEES, of New Jersey, has

signed the Palisades Park bill and the Appropriation bill which carries an item of $50,000 to aid in the purpose of preserving the Palisades and in establishing an inter-State park along the top of the bluff on the high rocks.

Secretary Wilson has authorized Professor Willis L. Moore, chief of the Weather Bureau, to create three new forecasting divisions, under the general authority of the last appropriation act. These divisions have been selected as follows: New England, headquarters at Boston; Western Gulf States, headquarters at Galveston, and Central Rocky Mountain plateau, headquarters at Denver. This will make a total of seven forecasting divisions in the weather service.

The steamship *Discovery*, built for the British Antarctic Expedition, was launched on March 21st, from the yards of the Dundee Shipbuilders' Company. We gave last week some account of the ship and the scientific staff of the expedition.

The following item is from the New York *Evening Post* of March 20th: "Peculiar circumstances surround the case of William Wallace, ex-Superintendent of Buildings at the Museum of Natural History, who resigned by request on January 10th. A lawsuit is under way before Judge Marean in the Kings County Supreme Court, special term, to-day, in which Mr. Wallace is alleged to have borrowed money as an agent of the Museum and appropriated it to his own uses. This money, it is further alleged, was borrowed from the contractors who are at work on the new buildings of the Museum. Work has been stopped because Mr. Wallace is alleged to have made contracts which he had no power to make. In reply to those who associate the facts that Mr. Wallace had borrowed money of the contractors and had then arranged contracts with them, Comptroller Coler, William E. Dodge, and others who are acquainted with the affairs of the Museum maintain a serious silence. The matter has been put in the hands of Edward M. Shepard, and to him each person referred inquirers. Mr. Shepard explained to-day that an investigation into Mr. Wallace's affairs was being made by the Museum authorities. "What you want to know, I suppose, is Mr. Wallace's exact offence," said Mr. Shepard. "On that subject I cannot talk. The investigation, which will probably take three weeks, will establish that question. If Mr. Wallace has had any wrong doing with the contractors, it is so far a matter between themselves. This I will say, however, that if any contractor has lent money to Mr. Waliace, and then received contracts from Mr. Wallace's hands without the approval of the trustees, I do not think the contractor is in an enviable position, and I do not believe the contract would be legally valid."

We learn from *Nature* that a small zoological expedition has started for the Malay Peninsula. It consists of Mr. N. Annandale, who was a member of the 'Skeat' expedition to the Siamese Malay States in 1899, and Mr. H. C. Robinson, hon. research assistant in the Zoological Department of University College, Liverpool. They intend to settle for a year in the native State of Jalor, near the east coast of Lower Siam, and to explore the neighborhood of Patani and Biseret. Collections will be made in all branches of natural history, while one of the special objects of the expedition is the study of the pre-Malayan tribes of Negrito stock who inhabit the center of the peninsula. A thorough investigation will also be made of the fauna—both living and extinct—of certain very large limestone caves which are found in the district, and are said to extend for great distances underground. The birds of the district will also be studied, and observations made on mimicry and allied phenomena. The ethnographical work ought to be interesting, since Jalor is on the borderland in which the Siamese and Malay races meet. Mr. Robinson is supplied with dredges and townets for the investigation of the marine fauna, and he proposes, by the method of pumping sea-water through fine silk nets, to make a collection of the surface plankton of the Red Sea and Indian Ocean on the voyage out.

According to the New York *Evening Post*, Dr. W. A. Kuflewski, chairman of the Special Committee appointed by the Chicago Public Library Board to consider the advisability of sterilizing the books in the library for the purpose of preventing the spread of disease, re-

ported to the trustees at their meeting on February 18th, recommending that some system be adopted for freeing the pages of the volumes from bacilli. Dr. Kuflewski exhibited several glass tubes filled with germs taken from the pages of library books. The bacilli represented a hundred different poisons and germs of disease. He said that all the fifty books examined by him during the investigation were found to be more or less infected. He said there was no doubt that disease was spread by the books. He advised that a system of sterilizing the volumes by the dry process be adopted immediately.

THE New York *Evening Post* reports that the Hon. John Dryden, Ontario Minister of Agriculture, recently announced in the Legislature that a complete change of policy had been decided upon in regard to the efforts to stamp out the San José scale. It had been found that cutting down infected orchards would prove far too costly to be continued. To continue it would have meant an expenditure of nearly $500,000 as a partial compensation to fruit growers. The new policy is to educate fruit-growers to destroy the pest without cutting down the trees. Experiments indicated that by systematic work this could be accomplished.

THE collection of mounted birds at the University of Michigan, including nearly fifteen hundred specimens, has been rearranged. The birds that are native of Michigan are in three cases on the east side of the bird room. Those in the case farthest north are birds to be found north of Ann Arbor, those in the middle case birds in the neighborhood, and those in the third case birds living to the south of Ann Arbor. The west side of the bird room is occupied with cases containing specimens from many different parts of the world. These are scientifically arranged. Besides the specimens in the cases, thirty-six bird groups have been arranged. These are mounted in their natural surroundings, often with nest, eggs and young. Each group is a picture of bird life. In addition to the mounted specimens in the bird room of the museum, the University possesses nearly four thousand skins for use in scientific study in the class room.

UNIVERSITY AND EDUCATIONAL NEWS.

SIR WILLIAM MCDONALD has made another large gift to McGill University, namely $150,000, for endowments for the chair of chemistry, now held by Professor Harrington, and for the chair of botany, now held by Professor Penhallow, and for an addition to the endowment of the chair of physics now held by Professor Cox.

TEACHERS College, Columbia University, has received an anonymous gift of $100,000 for a building for its experimental school. The building will provide for 50 children in the kindergarten and 240 in the elementary grades, with special classes in sewing, cooking, manual training and music. There will also be a gymnasium, baths, library, reading rooms and accommodations for evening classes, club meetings and social gatherings for the people of the community. This experimental school of the Teachers College is, of course, in addition to the Horace Mann school for which a new building is in course of construction.

THE present Legislature of the State of California has passed measures of importance for the two great universities of the State, and these have been signed by the Governor. The sum of $200,000 was appropriated for the support of the University of California, and a further contingent appropriation of $50,000 was made. Stanford University was, as we have already noted, given additional power to accept and hold funds, and its property was in part exempted from taxation.

THE last session of the State Legislature voted to place the North Dakota Agricultural College upon a permanent and fixed income in place of the heretofore uncertain bi-annual appropriation. One-fifth mill is assessed upon all taxable property in the State for the support of the College. An appropriation of $50,000 was made for needed buildings and improvements, and $18,000 to meet current expenses until the mill tax becomes available. A new chemical laboratory is to be built during the present season.

IT is reported that German-American citizens of Baltimore will collect $100,000 toward the endowment of the Johns Hopkins University, and that $600,000 of the million dollar fund have been secured.

THE Chicago *Tribune* reports that the Armour Institute of Technology will be amalgamated with the University of Chicago. The property of the Institute is valued at about $3,000,000, and there are about 1,000 students in attendance.

AN anonymous gift of $60,000 has been made to Allegheny College, at Meadville, Pa., on condition that $140,000 in addition be collected.

THE late Charles A. Converse, of Norwich, has bequeathed about $200,000 for public purposes, including $80,000 to the Norwich Free Academy for an art collection.

MRS. CHARLOTTE T. GASSETTE has given $10,000 to Albion College, at Albion, Mich., for a library building.

THE Manufacturers' Association in New York has appropriated $2,000 for a scholarship. Information concerning the terms on which it will be awarded can be obtained by addressing Mr. James T. Hoile, secretary of the association, 196 Montague street, Brooklyn.

THE medical building and the south building of the Iowa State University have been destroyed by fire. The loss is estimated at $250,000, and is only in part covered by insurance.

IN regard to the troubles at the Royal Engineering College at Coopers Hill, Lord George Hamilton has now consented to let the Board of Visitors meet the dismissed professors. He has also added to the Board of Visitors representatives of the Universities of Oxford, Cambridge and London, who are to be members of a committee that will report upon the working, discipline and constitution of the College, and the relations of the visitors, president and teaching staff.

DURING the latter part of June Professor Geo. F. Atkinson will deliver a series of lectures on 'Nature Study' at the summer school of the University of North Carolina. The lectures will deal with topics on 'Plant Life' and will be given before teachers. Professor Atkinson will return to Ithaca, N. Y., in time to take charge of the botanical work in the summer school of Cornell University.

PROFESSOR FRANK A. FETTER has resigned his position at Stanford University to accept a professorship of political science at Cornell University.

DR. DAVID EUGENE SMITH, principal of the State Normal College, at Brockport, N. Y., has been appointed professor of mathematics in Teachers College, Columbia University. Dr. Smith was graduated from Syracuse University in 1881, and is well known for his series of mathematical text-books and writings on the teaching and history of mathematics.

CAPTAIN WILLIAM CROZIER, of the Ordnance Department, has declined the appointment as professor of natural and experimental philosophy at the U. S. Military Academy at West Point, N. Y.

PRESIDENT JEROME H. RAYMOND has resigned the presidency of the University of West Virginia at Morgantown. There have been troubles in the faculty, and, as we have already noticed, two of the members who were dismissed have brought suit against President Raymond. The regents of the university have, however, in accepting the resignation, paid a high tribute to the services of Dr. Raymond. Dr. Raymond is now going abroad and on his return will accept a chair in the University of Chicago.

THE statement that Dr. W. T. Jordan, of the University of Tennessee, has been offered the presidency of the University of Alabama is not correct as the trustees will not elect a president until their meeting in June. Dr. Jordan's name has, however, been prominently mentioned in connection with the position.

THE following lecturers have been appointed at Yale University: Dr. Henry F. Davies, lecturer on esthetics and patristic philosophy; George R. Montgomery, lecturer in philosophy; Dr. Stuart Rowe, lecturer in pedagogy; Dr. William M. Hess, lecturer in philosophy.

MR HERBERT F. ROBERTS, instructor in botany in Washington University, St. Louis, has been elected to the chair of botany in the Kansas State Agricultural College.

PROFESSOR ANTON. FREIHERR VON EISELSBERG, of Königsberg, has been chosen to succeed the late Professor Eduard Albert in the chair of surgery at Vienna.